

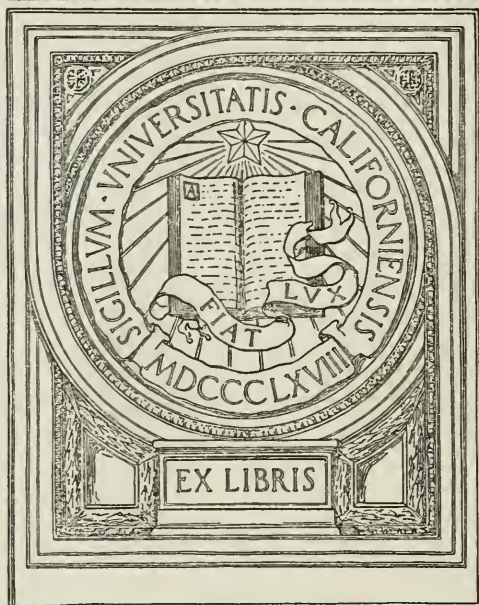
METROPOLITAN WATER AND SEWERAGE BOARD

NINETEENTH ANNUAL REPORT

DECEMBER 31, 1919

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NINETEENTH ANNUAL REPORT

OF THE

METROPOLITAN WATER AND
SEWERAGE WORKS

FOR THE YEAR 1919



BOSTON

WRIGHT & POTTER PRINTING CO., STATE PRINTERS

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METROPOLITAN DISTRICT COMMISSION.

METROPOLITAN WATER AND SEWERAGE WORKS.

To the Honorable the Senate and House of Representatives of the Commonwealth of Massachusetts in General Court assembled.

The Metropolitan District Commissioner has already presented to your Honorable Body an abstract of the account of the receipts, expenditures, disbursements, assets and liabilities of the Metropolitan Water and Sewerage Board for the fiscal year ending on November 30, 1919, and now presents a detailed statement of the doings of said Board and its successor, the Metropolitan District Commission, for the calendar year ending on December 31, 1919. Said Board was abolished by Chapter 350 of the General Acts of 1919 and its powers, duties and responsibilities transferred to said Commission by the terms of said Act.

NINETEENTH ANNUAL REPORT.

I. ORGANIZATION AND ADMINISTRATION.

BOARD, OFFICERS AND EMPLOYEES.

The term of office of Edward A. McLaughlin expired on March 20 and he was reappointed for the term of three years next succeeding. At the end of the fiscal year the Board consisted of Henry P. Walcott, chairman, Edward A. McLaughlin and James A. Bailey. William N. Davenport continued as secretary, Alfred F. Bridgman as purchasing agent and Miss Alice G. Mason as bookkeeper.

There are also employed in the administrative office a paymaster, an assistant in auditing, a first clerk, two general clerks, two stenographers and clerks, a telephone operator, and a janitor with two assistants, both of whom act as watchmen.

Such general conveyancing work and investigation of real estate titles in the different counties as have been called for during the year have been performed by George D. Bigelow.

The consulting engineers of the Board have been Hiram F. Mills and Frederic P. Stearns, who were called upon for services when matters arose which required their consideration.

Mr. Stearns died at the close of the year. From the date of his appointment in 1887 as Engineer of the State Board of Health he had been intrusted with the active consideration of some of the most vital questions affecting the Metropolitan District.

The investigations which led to the adoption of the present Metropolitan Water Supply, the treatment of the sewage disposal of the District and the improvement of the Charles River Basin with its development into one of the most attractive features of the Metropolitan Park System, indicate in some measure the scope of his varied and always useful efforts.

There was no doubt in any mind that he was the one person most competent to carry out the work of construction of the Metropolitan Water System, which he as Engineer of the State Board of Health had had so large a share in designing, and until the completion of the most important works of construction he was the Chief Engineer of the Metropolitan Water Board and its successor, the Metropolitan Water and Sewerage Board. He was also in active charge of the many important tasks imposed by legislation upon the Board in connection with the proposed extensions of the systems of water supply and sewerage.

Upon the completion of the larger works of the Metropolitan Water System he resigned his office and entered upon the general practice of his profession as consulting engineer. He was at once appointed one of the consulting engineers of the Board and rendered until his death services of the most valuable character.

It is unnecessary to rehearse the distinctions of his later life; they were gained in many fields and will remain permanent monuments to his memory.

On behalf of the Metropolitan Water and Sewerage Board the Metropolitan District Commissioner desires to make record of the loss of a most competent adviser, of a much beloved associate and of a citizen always animated by a sincere and unselfish devotion to the public interests.

William E. Foss is Chief Engineer of Water Works and John L. Howard, Assistant to the Chief Engineer. The following are superin-

tendents of departments under the direction of the Chief Engineer: Eliot R. B. Allardice, Superintendent of the Wachusett Department; Frank S. Hart, who succeeded Charles E. Haberstroh on his retirement on February 12, 1919, Superintendent of the Sudbury and Cochituate Works and of the portion of the Weston Aqueduct above the Weston Reservoir; Samuel E. Killam, Superintendent in charge of the Weston Reservoir and the remaining portion of the Weston Aqueduct, and of all distributing reservoirs and pipe lines within the Metropolitan Water District; and Arthur E. O'Neil, Superintendent of the several water works pumping stations.

The average engineering force employed on construction and maintenance during the year has included, in addition to the Chief Engineer, 1 assistant to Chief Engineer, 4 department superintendents, 1 division engineer, 7 assistant engineers and 31 others in various engineering capacities, and as sanitary inspectors, clerks, stenographers and messengers, the total force numbering 45.

A maintenance force in addition to those engaged in engineering capacities, as above mentioned, numbering upon the average during the year 288, has been required at the pumping stations, upon reservoirs, aqueducts, pipe lines and upon minor construction work. At the end of the year this force numbered 285.

Frederick D. Smith is Chief Engineer of Sewerage Works. He has been assisted by Henry T. Stiff, Division Engineer in charge of the office and drafting, by 4 assistant engineers and by 13 others employed in different engineering capacities, and by two stenographers and clerks.

The maximum engineering force employed at any one time during the year on the construction and maintenance of the Sewerage Works was 23.

The regular maintenance force required in addition for the operation of the pumping stations, the care and inspection of the sewers, and for other parts of the Sewerage Works, exclusive of the engineers, on the average has been 152.

The whole regular force of the Sewerage Department at the end of the year numbered 174, of whom the Chief Engineer and 16 assistants and draftsmen were engaged in general upon the works, and of the remainder, 93 were employed upon the North System and 64 upon the South System.

The maximum number of men employed upon contracts on the Sewerage Works during the year was for the week ending August 10, when the number amounted to 60.

II. METROPOLITAN WATER DISTRICT.

The Metropolitan Water District now comprises the cities of Boston, Chelsea, Everett, Malden, Medford, Melrose, Newton, Quincy, Revere and Somerville, and the towns of Arlington, Belmont, Lexington, Milton, Nahant, Stoneham, Swampscott, Watertown and Winthrop, — in all 10 cities and 9 towns. The District has an area of 174.8 square miles, no additional municipalities having been admitted into the District during the year. Its population, according to the State Census taken for April 1, 1915, was 1,201,300. The population of the District on July 1, 1919, the date upon which calculations for the Water Works are based, was estimated as 1,313,070.

III. METROPOLITAN WATER WORKS — CONSTRUCTION.

The total amount expended for the construction and acquisition of the Metropolitan Water Works since the passage of the Metropolitan Water Act in the year 1895 has been \$43,257,951.63.

The total amount expended during the calendar year on account of the construction and acquisition of works has been \$100,880.98. The details of this expenditure are as follows: — For the construction of a 12-inch metropolitan water main in West Roxbury and under Neponset River to provide an additional water supply for the town of Milton and the Hyde Park district of the city of Boston, the sum of \$11,589.18; to provide an additional water main for the supply of the East Boston district of the city of Boston, \$29,357.77; the construction of a 16-inch metropolitan water main to provide an additional supply of water for the town of Lexington, \$34,871.75; for the completion of the work of providing an additional water supply for Watertown and Belmont, \$5,619.54; for the relocation of meters and connections, \$13,018.34; and for other minor works, stock on hand, administration and engineering expenses, the sum of \$6,424.40.

The work of relocating Venturi meters on pipe lines acquired from the city of Boston and of making additional connections, which had not been completed owing to shortage of labor, was resumed early in the year, but on account of heavy street traffic and numerous under-

ground structures progress was necessarily slow so that the work has not been entirely completed.

The contract for the construction of an additional 36-inch low-service pipe line to provide an additional water supply for East Boston was made in August and the work completed late in November. The new pipe line was connected with the distribution system and put into service on December 18.

The work of laying a 16-inch northern extra high-service pipe line to provide an additional water supply for the town of Lexington was begun in September and all but a small portion of the line had been completed at the end of the year. On account of delay in receiving pipes from the foundry, the remaining work will be done by water works employees early in 1920.

The construction of the southern extra high-service 12-inch pipe line in Poplar Street, West Roxbury, for the reinforcement of the water supply of Hyde Park and Milton, parallel with a similar pipe line owned by the city of Boston and used jointly with the Commonwealth, was completed with the exception of resurfacing the street. This was deferred until spring on account of unfavorable weather. The new pipe line will be connected with the distribution system early in 1920. It was necessary to delay the laying of the flexible jointed pipes under the Neponset River on account of shortage of labor and unfavorable weather.

IV. WATER WORKS — MAINTENANCE.

The maintenance and operation of the Metropolitan Water Works during the past calendar year have required the expenditure of \$643,795.85.

(1) STORAGE RESERVOIRS.

The water in the Wachusett Reservoir reached its highest elevation, 395.93, on May 23, 0.93 of a foot above high-water mark. From that time the water subsided until it reached elevation 389.59 on November 1. At the end of the year the water had reached elevation 392.03, the highest elevation attained at the end of any year.

The Sudbury Reservoir was about 0.76 of a foot below the crest of the overflow at the beginning of the year. Flashboards were put in place April 18 and the water allowed to rise until it was 1.25 feet above the crest on June 5. Flashboards were removed from the

overflow November 21 and at the end of the year the water was 0.99 of a foot below the crest. The level of the water in Framingham Reservoir No. 3 varies somewhat on account of the discontinuance of the discharge of water into it from Sudbury Reservoir at times when the Sudbury power station is not in operation. The flashboards were kept on the overflow all the year and the elevation of the water in the reservoir varied from 182.53 to 186.84. Water was drawn from Lake Cochituate for the water supply from January 28 to April 3.

It has not been necessary to draw water for the supply of the Metropolitan District from Framingham Reservoir No. 1, Framingham Reservoir No. 2, Ashland, Hopkinton and Whitehall reservoirs.

(2) AQUEDUCTS.

The Wachusett Aqueduct was in service for the passage of water from the Wachusett Reservoir to the Sudbury Reservoir during the whole or portions of 292 days. The quantity of water flowing through the aqueduct was equal to an average of 92,336,000 gallons per day for the entire year, which is 16,331,000 gallons less than the daily average flow in 1918. All of the water drawn from the reservoir into the aqueduct was used before its admission for the development of electric energy.

For distribution to the cities and towns of the Metropolitan District water was drawn through the Sudbury Aqueduct to the Chestnut Hill Reservoir every day in the year, the daily average for the whole year being 65,568,000 gallons, a decrease of 9,065,000 gallons per day from that discharged in 1918.

The Weston Aqueduct was in use 303 days, the quantity of water delivered through the aqueduct being equivalent to a daily average of 47,509,000 gallons, a decrease of 3,303,000 gallons from that delivered in the previous year.

Water was discharged through the Cochituate Aqueduct on 65 days during the year, the total quantity being 713,900,000 gallons.

(3) PUMPING STATIONS.

The total amount of water pumped at all the pumping stations was 29,393,480,000 gallons, which is 3,800,890,000 gallons, or 11.45 per cent, less than in the previous year.

The following are the several pumping stations:—

	Number of Engines.	Contract Capacity per Day (Gallons).	Lift (Feet).
Chestnut Hill high-service station,	4	66,000,000	138
Chestnut Hill low-service station,	3	105,000,000	60
Chestnut Hill low-service station,	1	40,000,000	130
Spot Pond station,	2	30,000,000	125
Arlington station,	3	6,000,000	290
Hyde Park station,	2	6,000,000	140

The amount expended for the operation of the stations was \$195,-964.08, which is \$1,573.10 more than for the year 1918.

The total amount of coal purchased during the year was 10,028.28 gross tons, of which 7,128.66 tons were bituminous and 2,899.62 tons anthracite. All the anthracite coal was screenings. The average cost of bituminous coal in the bins at the various stations varied from \$6.63 to \$7.79, and the average cost of anthracite coal varied from \$2.90 to \$5.91 per gross ton.

(4) PROTECTION OF THE WATER SUPPLY.

The Marlborough Brook filter-beds, located in the southerly part of Marlborough, the Sterling filter-beds at Sterling, as well as the smaller filter-beds near Sterling Junction, the Worcester County Training School at West Boylston and the swimming pool at Southborough, have been in successful operation and required only the usual attention during the year.

The Pegan Brook pumping station, located in Natick, at which is pumped upon the filter-beds the surface drainage of about one square mile in the thickly settled portions of that town, was in operation on 272 days in the year.

The Sanitary Inspector and his assistants and members of the maintenance force have maintained a constant inspection of the watersheds.

Chemical examinations of the waters used were made by the State Department of Health, and in addition, microscopical and bacterial examinations were made by the Board. These examinations enable the Board to take measures to remedy any difficulties which are found to exist.

The quality of the water brought to the Metropolitan District continues to be satisfactory both in taste and appearance. This condition results in a large measure from the fact that it is still possible to reject some of the sources which were in use before the extension of the water works to the South Branch of the Nashua River. The water derived from the Wachusett watershed has been superior to that coming from the Sudbury and Cochituate sources. The first-named supply, so far as possible, has been that conveyed to the District; the others have been wasted to a greater or less extent as occasion has permitted.

The time is approaching when all the sources will be required for the supply of the District. When that time arrives it may be necessary to filter the less desirable waters in order to bring them to the standard of excellence to which the District has become accustomed since the establishment of the Metropolitan Water System.

During the year the Board acquired the fee of 50 acres of land in Boylston, 13.43 acres in Sterling and 17.86 acres in West Boylston for the protection and improvement of the water supply.

(5) CLINTON SEWERAGE WORKS.

The Board continued the operation of the works for the disposal of the sewage of the town of Clinton on lands acquired for the purpose in the town of Lancaster, under authority of Chapter 557 of the Acts of the year 1898.

The quantity of sewage pumped to the filter-beds averaged 103,000 gallons per day more than in 1918 and the cost of filtration was \$7.61 per million gallons more than in the previous year. This high cost of filtration was due in part to higher wages and increased cost of supplies, but largely to the condition of the filters which have been overworked for some time. This condition has been chiefly brought about by the large amount of ground water and greasy mill wastes which now enter the Clinton sewers and could be materially improved at small expense if the town of Clinton, under authority of Chapter 433 of the Acts of 1909, would order all surface water drains disconnected from the sewers and require the large manufacturing companies to keep greasy wastes from wool washing processes out of the same.

(6) WACHUSETT POWER PLANT.

The hydro-electric power station at the Wachusett Dam was operated on 279 days during the year. The energy not used in connection with the operation of the Metropolitan Water Works was sold to the New England Power Company and the Edison Electric Illuminating Company under a contract which provided for the construction of a 66,000-volt transmission line between the Wachusett and Sudbury power stations, to make possible the most advantageous use of the power. This line had not been put into regular service at the end of the year. As in the previous year, all the water from the reservoir used for water supply purposes has been used to generate electric energy. The operation of the plant continues to be successful, the gross earnings for the year being \$40,-491.12. The cost of operating the plant has been \$24,162.36, the net earnings \$16,328.76, and the net earnings per thousand kilowatt hours sold \$2.145.

(7) SUDBURY POWER PLANT.

The hydro-electric power station at the Sudbury Dam was operated on 303 days during the year. The entire output, with the exception of a small amount of energy used for lighting the station and operating the electrically driven accessories, has been sold to the Edison Electric Illuminating Company of Boston under a contract made in 1914. The gross earnings for the year were \$32,736.58, the cost of operating the plant \$17,272.33, and the net earnings \$15,-464.25. The net earnings per thousand kilowatt hours sold were \$2.952.

(8) FORESTRY.

Parcels of water works land in Sterling, west of the North Dike and on Beaman Street, West Boylston, aggregating 38 acres, which had been planted and since burned and cleared for planting again, were replanted with 35,700 four-year-old Scotch pine seedlings and 1,700 seven-year-old white pine seedlings; and 38 acres along the margins of the Wachusett Reservoir in Clinton, Sterling and West Boylston were filled in where the original trees had failed with 11,200 five-year-old white pine seedlings from the Oakdale nursery.

Twenty-two acres of land bordering on the Wachusett Reservoir and tributary streams, which had been recently burned over or were grown to chestnut trees seriously damaged by the chestnut bark

disease or infested with gypsy moths, were cleared for planting with pine seedlings.

Sprouts and undergrowth, which were interfering with the pines planted during the last few years, were cleared from about 98 acres of land along the open channel of the Wachusett Aqueduct; thinning was made on 3 acres of timber land on the margin of the Wachusett Reservoir; and the improvement thinning begun and carried on in previous years of a portion of Big Crane Swamp in Westborough was continued, about 3 acres being improved.

There are now in the Oakdale nursery 119,250 seedlings from two to eight years old.

Since the beginning of forestal work on Wachusett Reservoir marginal lands 1,523 acres have been planted.

A marginal strip 100 feet in width along main highways bordering water works land around the Wachusett Reservoir was cleared of all brush and undergrowth and trees were trimmed, as a means of preventing roadside grass fires from spreading to improved and planted water works land. At the end of the year 99 acres along $6\frac{1}{4}$ miles of highway had been thus improved.

From the Sudbury Reservoir nursery 54,300 white pine seedlings were planted on cleared land on Farm Road; 42,000 on Pine Hill; 11,400 on A. J. Newton land; and 10,000 four-year-old and 4,350 two-year-old seedlings were used to replace trees lost by fire and for filling in at the Sudbury Reservoir.

There were also 3,750 pines used to replace dead trees on the southerly shore of Framingham Reservoir No. 3 and 5,000 used at different points about Lake Cochituate.

About 85 acres of woodland at Pine Hill and near Farm Road at the Sudbury Reservoir were cleared in preparation for setting out pine seedlings.

Along the Weston Aqueduct 6,500 four-year-old pine seedlings and along the Sudbury and Cochituate aqueducts 4,200 seedlings have been planted during the year.

The work of attempting to check the spread of the pine-tree weevil, gypsy moth and elm-leaf beetle has been continued as far as practicable by spraying, painting egg clusters and burning moth nests.

(9) RAINFALL AND WATER SUPPLY.

The rainfall for the year was above the average, and somewhat more than in the preceding year. On the Wachusett watershed the

rainfall was 49.05 inches, on the Sudbury watershed 45.64 inches and on the Cochituate watershed 46.07 inches, while the averages for the periods covered by the records have been, respectively, 44.87 inches, 44.53 inches and 45.14 inches.

The Wachusett watershed yielded a daily average of 1,257,000 gallons per square mile, which is 18.25 per cent above the average for the past twenty-three years; the Sudbury watershed yielded a daily average of 988,000 gallons per square mile, which is 1.33 per cent above the average for the past forty-five years; and the Cochituate watershed yielded a daily average of 1,056,000 gallons per square mile, which is 14.91 per cent above the average for the past fifty-seven years.

(10) WATER CONSUMPTION.

During the year the quantity of water supplied to the Metropolitan Water District amounted to a daily average of 120,593,500 gallons as measured by the Metropolitan Water Works meters, which was equivalent to 95 gallons for each person in the District. This quantity was 9,170,500 gallons less than the average daily consumption of the preceding year. This decrease seems to have been partly due to the reduced industrial activity resulting from the termination of the war and to the mild winter. It is anticipated that a still further reduction may be made in the future when the work of installing meters on service pipes is completed.

Acting under authority conferred by several statutes and arrangements which have been made, water has been supplied to a limited extent outside of the Metropolitan Water District. There has been drawn from the open channel of the Wachusett Aqueduct for the use of the Westborough State Hospital a daily average quantity of 176,400 gallons. The town of Framingham has, under the provisions of the statute, drawn indirectly from Farm Pond a daily average quantity of 480,822 gallons and directly from the Sudbury Aqueduct 471,901 gallons. A portion of the town of Saugus has been supplied through the city of Revere with an average of 28,700 gallons daily. The United States Government, for use on Peddock's Island, has been supplied with a daily average of 55,600 gallons. The sums charged for the water thus supplied have amounted to \$7,652.15.

V. WATER WORKS — FINANCIAL STATEMENT.

The financial abstract of the receipts, disbursements, assets and liabilities of the Board for the State fiscal year, beginning with December 1, 1918, and ending with November 30, 1919, was, in accordance with the requirements of Chapter 235 of the Acts of the year 1906, presented to the General Court in January last, and a copy of this financial abstract is printed as Appendix No. 5.

As required by said chapter a detailed statement of its doings for the calendar year 1919, in relation to the Metropolitan Water Works, is herewith presented.

CONSTRUCTION.

(1) WATER LOANS — RECEIPTS AND PAYMENTS.

Total loans authorized to January 1, 1920,	\$42,980,000 00	
Receipts from the sales of property applicable to the construction and acquisition of works: —		
For the period prior to January 1, 1919,	\$257,336 86	
For the year ending December 31, 1919,	2,005 81	
		259,342 67
Receipt from the town of Swampscott for admission to District (St. 1909, c. 320),		90,000 00
Total amount authorized to January 1, 1920,	\$43,329,342 67	
Amounts approved by Board for payments out of Water Loan Fund: —		
Payments prior to January 1, 1919,	\$43,157,070 65	
Approved for year ending December 31, 1919,	100,880 98	
		43,257,951 63
Amount authorized but not expended January 1, 1920,	\$71,391 04	

(2) TOTAL WATER DEBT, DECEMBER 31, 1919.

Water Loan Outstanding, Sinking Fund and Debt.

Bonds issued by the Treasurer of the Commonwealth: —

Sinking fund bonds (3 and 3½ per cent),	\$41,398,000 00	
Serial bonds (3½, 4 and 4½ per cent),	1,515,000 00	
Total bond issue to December 31, 1919,	\$42,913,000 00	
Serial bonds paid prior to January 1, 1919,	\$141,000 00	
Serial bonds paid in 1919,	37,000 00	
		178,000 00
Total bond issue outstanding December 31, 1919,	\$42,735,000 00	

Gross water debt, \$42,735,000 00
 Sinking fund December 31, 1919, 15,904,545 14

Net water debt December 31, 1919, \$26,830,454 86
 A decrease for the year of \$909,710.30.

(3) METROPOLITAN WATER LOAN AND SINKING FUND,
 DECEMBER 31, 1919.

YEAR.	Authorized Loans.	Bonds issued (Sinking Fund).	Bonds issued (Serial Bonds).	Sinking Fund.
1895,	\$27,000,000	\$5,000,000	-	\$226,286 05
1896,	-	2,000,000	-	699,860 70
1897,	-	6,000,000	-	954,469 00
1898,	-	4,000,000	-	1,416,374 29
1899,	-	3,000,000	-	1,349,332 97
1900,	-	1,000,000	-	1,573,619 72
1901,	13,000,000	10,000,000	-	1,662,426 95
1902,	-	3,500,000	-	2,256,803 81
1903,	-	1,500,000	-	2,877,835 59
1904,	-	2,500,000	-	3,519,602 92
1905,	-	650,000	-	4,207,045 69
1906,	500,000	1,350,000	-	4,897,822 62
1907,	-	-	-	5,643,575 69
1908,	398,000	-	-	6,419,283 28
1909,	900,000	398,000	-	7,226,262 31
1910,	80,000	500,000	-	8,089,902 91
1911,	212,000	-	\$200,000	8,553,437 44
1912,	600,000	-	190,000	9,829,356 80
1913,	108,000	-	-	10,767,701 68
1914,	-	-	258,000	11,533,453 45
1915,	-	-	490,000	12,491,245 25
1916,	-	-	66,000	13,268,199 36
1917,	-	-	150,000	14,036,278 88
1918,	115,000	-	-	14,870,834 84
1919,	67,000	-	161,000	15,904,545 14
	\$42,980,000	\$41,398,000	\$1,515,000	-

(4) WATER ASSESSMENT, 1919.

The following water assessment was made by the Treasurer of the Commonwealth upon the various municipalities: —

Sinking fund requirements,	\$261,966 36
Serial bonds,	\$43,000 00
Less premium,	32 20
	<hr/>
	42,967 80
Interest,	1,490,743 33
Maintenance: —	
Appropriated by Legislature,	\$647,200 00
Less balance on hand,	5,431 74
	<hr/>
	641,768 26
	<hr/>
Total water assessment for 1919,	\$2,437,445 75

In accordance with Chapter 488, Acts of 1895, as amended in 1901, 1904 and 1906, the proportion to be paid by each city and town is based one-third in proportion to their respective valuations and the remaining two-thirds in proportion to their respective water consumption for the preceding year, except that but one-fifth of the total valuation and no consumption has been taken for the city of Newton, as it has not been supplied with water from the Metropolitan Works.

The division of the assessment for 1919 was as follows: —

CITIES AND TOWNS.	Assessment.	CITIES AND TOWNS.	Assessment.
Arlington,	\$24,320 83	Nahant,	\$4,567 76
Belmont,	12,596 72	Newton,	6,210 62
Boston,	1,805,104 07	Quincy,	78,083 57
Chelsea,	58,145 27	Revere,	34,950 55
Everett,	58,298 82	Somerville,	128,082 90
Lexington,	9,720 54	Stoneham,	10,437 14
Malden,	57,579 78	Swampscott,	13,267 02
Medford,	41,326 89	Watertown,	40,517 66
Melrose,	22,670 68	Winthrop,	18,639 15
Milton,	12,925 78		<hr/>
			\$2,437,445 75

(5) SUPPLYING WATER TO CITIES AND TOWNS OUTSIDE OF DISTRICT AND TO WATER COMPANIES.

Sums have been received during the year 1919 under the provisions of the Metropolitan Water Act, for water furnished, as follows: —

Town of Framingham,	\$5,945 04
City of Revere (on account of water furnished to a portion of the town of Saugus for 1918),	800 00
United States Government (for Peddock's Island),	1,429 29
Westborough State Hospital,	1,855 20
	<u>\$10,029 53</u>

The sums so received prior to March 23, 1907, were annually distributed among the cities and towns of the District; but since that date, in accordance with the provisions of Chapter 238 of the Acts of 1907, the sums so received have been paid into the sinking fund.

(6) EXPENDITURES FOR THE DIFFERENT WORKS.

The following is a summary of the expenditures made in the various operations for the different works: —

CONSTRUCTION AND ACQUISITION OF WORKS.	For the Year ending December 31, 1919.
Administration applicable to all parts of the construction and acquisition of the works,	\$3,180 96
Distribution system: —	
Low service: —	
Section 46 (additional water supply for the East Boston district of the city of Boston),	\$29,357 77
Southern high service: —	
Section 47 (additional water supply for Watertown and Belmont),	5,019 54
Real estate,	600 00
Northern extra high service: —	
New pumping engine at Arlington pumping station,	1,145 08
Section 45 (additional water supply for the town of Lexington),	34,871 75
Southern extra high service: —	
Section 44 (additional water supply for the town of Milton and the Hyde Park district of the city of Boston),	11,589 18
Meters and connections,	13,018 34
	<u>95,601 66</u>
Stock — pipes, valves, castings, etc., purchased and sent first to storage yards, and later transferred, as needed, to the various parts of the work: —	\$98,782 62
Amount received,	\$12,131 89
Transferred from storage yards to the various sections of the work and included in costs of special works,	10,033 53
	<u>2,098 36</u>
	<u>\$100,880 98</u>
Amount charged from beginning of work to January 1, 1919,	43,157,070 65
Total for construction and acquisition of works to January 1, 1920,	<u>\$43,257,951 63</u>

MAINTENANCE AND OPERATION.	For the Year ending December 31, 1919.	
Administration,	\$15,522	15
General supervision,	39,312	65
Taxes and other expenses,	45,227	28
Wachusett Department: —		
Superintendence,	\$11,236	44
Reservoir,	18,109	78
Forestry,	12,620	71
Protection of supply,	8,841	66
Buildings and grounds,	5,464	53
Wachusett Dam,	7,281	47
Wachusett Aqueduct,	11,754	18
Clinton sewerage system: —		
Pumping station,	1,988	13
Sewers, screens and filter-beds,	14,012	98
Sanitary inspection,	291	09
Swamp drainage,	5,772	43
Power plant,	21,641	00
Wachusett-Sudbury Power Transmission Line,	239	01
Payments under Industrial Accident Law and special benefit appropriations,	367	72
119,621		13
Sudbury Department: —		
Superintendence, Framingham office,	\$12,224	20
Ashland Reservoir,	3,217	56
Hopkinton Reservoir,	3,083	68
Whitehall Reservoir,	2,302	24
Framingham Reservoirs Nos. 1, 2 and 3,	10,473	88
Sudbury Reservoir,	8,550	88
Lake Cochituate,	7,450	65
Marlborough Brook filters,	2,208	09
Pegan filters,	6,596	14
Sudbury and Cochituate watersheds,	2,523	92
Sanitary inspection,	3,884	61
Cochituate Aqueduct,	3,173	81
Sudbury Aqueduct,	7,071	38
Weston Aqueduct,	6,043	42
Forestry,	9,231	01
Power plant,	9,418	01
Payments under Industrial Accident Law and special benefit appropriations,	351	64
97,805		12
Distribution Department: —		
Superintendence,	\$8,988	61
Pumping service: —		
Superintendence,	6,982	21
Payments under Industrial Accident Law and special benefit appropriations,		
765		91
Emergency pumping,	3,029	25
Arlington pumping station, pumping service,	13,666	72
Chestnut Hill low-service pumping station, pumping service,	93,672	04
Chestnut Hill high-service pumping station, pumping service,	39,289	77
Spot Pond pumping station, pumping service,	27,364	85
Hyde Park pumping station, pumping service,	11,193	33
<i>Amounts carried forward,</i>		\$317,483 33
\$204,952		69

MAINTENANCE AND OPERATION.		For the Year ending December 31, 1919.	
<i>Amounts brought forward,</i>		\$204,952 69	\$317,488 33
Distribution Department — <i>Con.</i>			
Bear Hill Reservoir,		298 70	
Chelsea Reservoir,		571 93	
Chestnut Hill Reservoir and grounds,		13,715 63	
Fells Reservoir,		1,436 80	
Forbes Hill Reservoir,		2,517 61	
Mystic Lake, conduit and pumping station,		1,471 81	
Mystic Reservoir,		5,590 02	
Waban Hill Reservoir,		338 90	
Weston Reservoir,		4,793 70	
Spot Pond,		9,387 65	
Buildings at Spot Pond,		1,833 76	
Pipe lines: —			
Low service,		31,740 94	
Northern high service,		6,874 70	
Northern extra high service,		193 88	
Southern high service,		7,872 92	
Southern extra high service,		154 26	
Supply pipe lines,		1,368 77	
Buildings at Chestnut Hill Reservoir,		4,802 89	
Chestnut Hill pipe yard,		3,307 12	
Glenwood pipe yard and buildings,		3,524 16	
Stables,		9,731 29	
Venturi meters,		1,717 54	
Measurement of water,		2,788 78	
Arlington pumping station, buildings and grounds,		860 02	
Hyde Park pumping station, buildings and grounds,		228 27	
Fisher Hill Reservoir,		3,465 54	
Bellevue Reservoir,		123 52	
Payments under Industrial Accident Law and special benefit appropriations,		643 72	
			326,307 52
Total for maintaining and operating works,			\$643,795 85

(7) DETAILED FINANCIAL STATEMENT UNDER METROPOLITAN WATER ACT.

The Commissioner herewith presents, in accordance with the requirements of the Metropolitan Water Act, a detailed statement of the expenditures and disbursements, receipts, assets and liabilities for the year 1919.

(a) *Expenditures and Disbursements.*

The total amount of the expenditures and disbursements on account of construction and acquisition of works for the year beginning January 1, 1919, and ending December 31, 1919, was \$100,880.98, and the total amount from the time of the organization of the

Metropolitan Water Board, July 19, 1895, to December 31, 1919, has been \$43,257,951.63.

For maintenance and operation the expenditures for the year were \$643,795.85.

The salaries of the commissioners, and the other expenses of administration, have been apportioned to the construction of the works and to the maintenance and operation of the same, and appear under each of those headings.

The following is a division of the expenditures according to their general character:—

GENERAL CHARACTER OF EXPENDITURES.		For the Year ending December 31, 1919.
CONSTRUCTION OF WORKS AND ACQUISITION BY PURCHASE OR TAKING.		
<i>Administration.</i>		
Commissioners,	\$1,583 34	
Clerks and stenographers,	1,172 91	
Stationery and printing,	188 72	
Postage, express and telegrams,	20 00	
Telephone, lighting, heating, water and care of building,	153 22	
Rent and taxes, main office,	59 77	
Miscellaneous expenses,	3 00	
		\$3,180 96
<i>Engineering.</i>		
Principal assistant engineers,	\$769 66	
Engineering assistants,	2,375 12	
Inspectors,	1,485 98	
Railroad and street car travel,	2 04	
Stationery and printing,	97 97	
Engineering and drafting instruments and tools,	25	
Engineering and drafting supplies,	51 91	
Telephone, lighting, heating, water and care of buildings:—		
Main office,	459 78	
Rent and taxes, main office,	179 30	
Unclassified supplies,	70 00	
Miscellaneous expenses,	34 70	
		5,526 71
<i>Construction.</i>		
Preliminary work:—		
Advertising,		60 50
Contracts, Distribution System:—		
F. A. Mazzur & Co., for furnishing and installing a centrifugal pumping unit at the northern extra high-service pumping station at Arlington, Mass., Contract 382,	\$970 00	
Michele DeSisto, for laying water pipes on Section 47, southern high service (additional water supply for Watertown and Belmont), Contract 387,	4,699 53	
U. S. Cast Iron Pipe & Foundry Co., for furnishing cast-iron water pipes and special castings, Contract 388,	7,778 82	
Amounts carried forward,	\$13,448 35	\$8,768 17

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1919.	
<i>Amounts brought forward,</i>	\$13,448 35	\$8,768 17
<i>Construction — Con.</i>		
<i>Contracts, Distribution System — Con.</i>		
Chapman Valve Mfg. Co., for furnishing screw-lift valves used in the construction of Section 44 of the southern extra high service (additional water supply for the town of Milton and the Hyde Park district of the city of Boston), Contract 391 (in part),	820 00	
Chapman Valve Mfg. Co., for furnishing screw-lift valves used in the construction of Section 45 of the northern extra high service (additional water supply for the town of Lexington), Contract 391 (in part),	1,590 00	
Chapman Valve Mfg. Co., for furnishing screw-lift valves used in the construction of Section 46 of the low service (additional water supply for the East Boston district of the city of Boston), Contract 391 (in part),	3,300 00	
Gibby Foundry Co., for furnishing manhole frames and covers, Contract 392,	655 70	
Warren Foundry & Machine Co., for furnishing cast-iron water pipes and special castings, for use on Section 44 of the southern extra high service (additional water supply for the town of Milton, Mass., and the Hyde Park district of the city of Boston), Contract 393 (in part),	3,583 39	
Warren Foundry & Machine Co., for furnishing cast-iron water pipes and special castings for use on Section 45 of the northern extra high service (additional water supply for the town of Lexington, Mass.), Contract 393 (in part),	14,916 69	
Warren Foundry & Machine Co., for furnishing cast-iron water pipes and special castings for use on Section 46 of the low service (additional water supply for the East Boston district of the city of Boston), Contract 393 (in part),	13,979 06	
Warren Foundry & Machine Co., for furnishing cast-iron water pipes and special castings, Contract 393 (in part),	3,287 37	
Vincenzo Grande, for laying water pipes in West Roxbury, Mass., Section 44 of the southern extra high service (additional water supply for the town of Milton and the Hyde Park district of the city of Boston), Contract 394,	2,761 59	
James Barletta for laying water pipes in Arlington, Mass., Section 45 of the northern extra high service (additional water supply for the town of Lexington, Mass.), Contract 395,	13,127 42	
Coleman Bros., for laying water pipes in Chelsea, Mass., Section 46 of the low service (additional water supply for the East Boston district of the city of Boston), Contract 396,	7,441 81	
		\$78,911 38
<i>Additional work: —</i>		
Labor,	\$7,767 53	
Freight and express,	3,351 00	
Traveling,	20	
Castings, ironwork and metals,	122 15	
Iron pipe and valves,	410 00	
Lumber and field buildings,	156 76	
Brick, cement and stone,	341 60	
Drain pipe,	22 18	
<i>Amounts carried forward,</i>	\$12,171 42	\$87,679 55

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1919.	
<i>Amounts brought forward,</i>	\$12,171 42	\$87,679 55
<i>Construction — Con.</i>		
<i>Additional work — Con.</i>		
Municipal and corporation work,	389 12	
Unclassified supplies,	9 49	
Miscellaneous expenses,	5 00	
		12,575 03
<i>Real Estate.</i>		
<i>Legal and expert: —</i>		
Conveyancing expenses,	\$26 40	
Settlements made by the Board,	600 00	
		626 40
		\$100,880 98
Amount charged from beginning of work to January 1, 1919,		43,157,070 65
Total amount of construction expenditures to January 1, 1920,		\$43,257,951 63
<i>MAINTENANCE AND OPERATION OF WORKS.</i>		
<i>Administration: —</i>		
Commissioners,	\$4,666 66	
Secretary and assistants,	7,336 13	
Rent,	767 01	
Repairs of building,	4 21	
Fuel,	83 04	
Lighting,	70 82	
Care of building,	581 28	
Postage,	129 00	
Printing, stationery and office supplies,	1,412 53	
Telephones,	135 27	
Traveling expenses,	198 21	
Miscellaneous expenses,	137 99	
		\$15,522 15
<i>General supervision: —</i>		
Chief engineer and assistants,	\$30,667 61	
Rent,	2,301 10	
Repairs of building,	301 67	
Fuel,	249 16	
Lighting,	220 75	
Care of building,	1,744 56	
Postage,	132 16	
Express and telegrams,	185 85	
Printing, stationery and office supplies,	1,269 88	
Telephones,	463 06	
Traveling expenses,	707 87	
Miscellaneous expenses,	1,063 98	
		39,312 65
<i>Amount carried forward,</i>		\$54,834 80

GENERAL CHARACTER OF EXPENDITURES.		For the Year ending December 31, 1919.	
Amount brought forward,		\$54,834 80	
Pumping service: —			
Superintendence,	\$6,982 21		
Labor,	103,991 93		
Fuel,	58,848 95		
Oil, waste and packing,	3,387 41		
Repairs,	16,779 62		
Small supplies,	2,178 80		
Payments under Industrial Accident Law and special benefit appropriations,	765 91		
Emergency pumping,	3,029 25		
		195,964 08	
Reservoirs, aqueducts, pipe lines, buildings and grounds: —			
Superintendents,	\$7,903 64		
Engineering assistants,	17,067 58		
Sanitary inspectors,	3,418 04		
Labor, pay roll,	229,275 96		
Labor, miscellaneous,	4,362 42		
Alterations and repairs of pumping stations,	2,530 62		
Alterations and repairs of other buildings and structures,	4,525 05		
Automobiles,	12,534 83		
Brick,	172 50		
Brooms, brushes and janitor's supplies,	546 55		
Castings, ironwork and metals,	1,704 38		
Cement and lime,	915 92		
Drafting and photo supplies,	674 06		
Electrical supplies,	5,859 31		
Fertilizer and planting material,	2,195 09		
Freight and express,	858 68		
Fuel,	3,686 75		
Gypsy moth supplies,	2,495 12		
Hardware,	2,061 87		
Hay and grain,	1,323 90		
Lighting,	323 51		
Lumber,	1,649 56		
Machinery,	2,789 29		
Paints and oils,	1,936 83		
Pipe and fittings,	1,245 88		
Postage,	104 22		
Printing, stationery and office supplies,	1,577 93		
Rubber and oiled goods,	644 31		
Stable expenses,	746 14		
Sand, gravel and stone,	341 92		
Traveling expenses,	3,487 64		
Telephones,	1,300 39		
Teaming,	5,184 90		
Tools and appliances,	3,836 86		
Vehicles, harnesses and fittings,	122 23		
Miscellaneous expenses,	3,921 57		
Amounts carried forward,		\$333,325 45	\$250,798 88

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1919.	
<i>Amounts brought forward,</i>	\$333,325 45	\$250,798 88
Contracts: —		
Boston Structural Steel Co., Contract 65-M, for furnishing and delivering 1,165 linear feet of picket fence complete at Mystic Reservoir in Medford, Mass.,	2,029 00	
Improvement and protection of water supplies,	5,488 56	
Water from city of Worcester,	5,563 60	
Payments under Industrial Accident Law and special benefit appropriations,	1,363 08	
		347,769 69
Payments in lieu of taxes,		45,227 28
		<hr/> \$643,795 85
Total expenditures for maintenance and operation,		

(b) *Receipts.*

The total amount of receipts from the operations of the Board and from sales of property for the year beginning January 1, 1919, and ending December 31, 1919, was \$100,637.94, and the total amount from the time of the organization of the Metropolitan Water Board, July 19, 1895, to December 31, 1919, has been \$1,599,015.64. The general character of these receipts is as follows: —

GENERAL CHARACTER OF RECEIPTS.	For the Year ending December 31, 1919.	
Applicable to the loan fund: —		
Land and buildings,	\$250 00	
Construction tools, supplies and reimbursements,	1,755 81	
		<hr/> \$2,005 81
Applicable to payment of interest, sinking fund requirements and expenses of maintenance and operation: —		
Proceeds from operations of the Board: —		
Rents,	\$3,847 00	
Land products,	7,602 53	
Electric energy,	71,901 08	
Maintenance labor, tools, supplies and reimbursements,	5,114 01	
Interest and unclassified receipts,	137 98	
		<hr/> 88,602 60
Applicable to the sinking fund: —		
Water supplied to cities and towns, water companies and others,		10,029 53
		<hr/> \$100,637 94
Amount credited from beginning of work to January 1, 1919,		1,498,377 70
		<hr/> \$1,599,015 64
Total receipts to January 1, 1920,		

The foregoing receipts have been credited to the various objects or works, as follows: —

SOURCES OF RECEIPTS.	For the Year ending December 31, 1919.
Supplying water outside of Water District,	\$10,029 53
Construction and acquisition of works: —	
Administration,	\$70 87
Sudbury Reservoir,	250 00
Distribution system,	1,755 36
	2,076 23
Maintenance and operation of works: —	
Administration,	\$286 15
General supervision,	369 06
Wachusett Aqueduct,	465 13
Wachusett Reservoir,	6,496 01
Wachusett electric power plant,	40,422 14
Sudbury system,	2,392 50
Sudbury electric power plant,	31,609 22
Distribution system,	5,395 11
Clinton sewerage system,	1,096 86
	88,532 18
	\$100,637 94
Amount credited from beginning of work to January 1, 1919,	1,498,377 70
	\$1,599,015 64

(c) *Assets.*

The following is an abstract of the assets of the Water Works, a complete schedule of which is kept on file in the office of the Commission: —

Office furniture, fixtures and supplies; engineering and scientific instruments and supplies; police supplies; horses, vehicles, field machinery, etc.; machinery, tools and other appliances and supplies; completed works, real estate and buildings connected therewith.

(d) *Liabilities.*

There are sundry bills for current expenses which have not yet been received.

Amounts on Monthly Estimates, not due until Completion of Contracts or until Claims are settled.

NAME.	Work.	Amount.
Joseph Hanreddy,	Contract 314, Section 7 of the Weston Aqueduct Supply Mains, in Newton, Mass.	\$10 00
Warren Foundry & Machine Co., . .	Contract 393 for furnishing cast-iron water pipes and special castings for the Distribution System.	6,311 74
Vincenzo Grande,	Contract 394, Section 44 of the southern extra high-service pipe line (additional water supply for the town of Milton and the Hyde Park district of the city of Boston).	487 34
James Barletta,	Contract 395, Section 45 of the northern extra high-service pipe line (additional water supply for the town of Lexington).	2,316 60
Coleman Bros.,	Contract 396, Section 46 of the low-service pipe line (additional water supply for the East Boston district of the city of Boston).	1,313 26

Settlements are pending with the following parties for land and easements taken in lands owned by them:—

New York, New Haven & Hartford Railroad Company, Frederique Ropp, Heirs of William H. Mason, Heirs of Ella Wood, Jack Calcia.

VI. METROPOLITAN SEWERAGE WORKS.

The North Metropolitan Sewerage District embraces the cities of Cambridge, Chelsea, Everett, Malden, Medford, Melrose, Revere, Somerville and Woburn, and the towns of Arlington, Belmont, Reading, Stoneham, Wakefield, Winchester and Winthrop and parts of the city of Boston and the town of Lexington, — comprising in all 10 cities and 8 towns, with an area of 100.32 square miles. The district has an estimated population, based upon the census of 1915, as of December 31, 1919, of 659,530. Of the total population it is estimated that 90.3 per cent, or 595,570 people, contribute sewage to the North Metropolitan System.

The South Metropolitan Sewerage District includes the cities of Newton, Quincy and Waltham, and the towns of Brookline, Milton, Watertown and Wellesley, and parts of the city of Boston and the town of Dedham, — a total of 4 cities and 5 towns. This district has an area of 110.76 square miles, with an estimated population as of December 31, 1919, of 510,100. According to the estimates made 79.9 per cent of this population, or 407,410, contribute sewage to the South Metropolitan System.

(1) NORTH METROPOLITAN SEWERAGE SYSTEM — CONSTRUCTION.

The amount expended for construction on account of the North Metropolitan System during the past year was \$112,531.93.

The plan adopted by the joint commission in July, 1914, for the disposal of the sewage of the town of Reading has been so modified that by the construction of works for pumping the sewage into the metropolitan sewers a satisfactory disposal of the sewage of the town may be obtained for several years, at a cost within the original appropriation. The Board was given authority by the Legislature of 1919 to construct these works and the work has been carried on during the year in accordance with this plan. Several sections of the sewer have been completed and it is expected that the extension will be ready for use before the end of the year.

The Board acquired by taking during the year easements in 1.921 acres of land in Woburn and Stoneham for the construction of the Reading Extension of the North Metropolitan Sewerage System.

(2) NORTH METROPOLITAN SEWERAGE SYSTEM — MAINTENANCE.

The cost of the maintenance and operation of the North Metropolitan System during the past year was \$234,588.14.

Sewers and Pumping Stations.

The metropolitan sewers in the North Metropolitan System now extend a distance of 65.375 miles, and the local sewers which are connected with the metropolitan sewers have a further length of 779.65 miles, involving 85,705 connections.

The sewage of the North Metropolitan District flows at first by gravity, but before being finally disposed of is lifted at different points by pumping and is finally discharged into the harbor from an outfall off Deer Island.

The daily average amount of sewage discharged into the harbor was 70,300,000 gallons, a daily average for each person contributing sewage of 118 gallons. The amount of sewage discharged was 3,800,000 gallons per day more than the discharge of the preceding year. The maximum discharge in any one day was 153,200,000 gallons.

The pumping stations operated for the North Metropolitan Sewerage System are as follows: —

	Number of Engines.	Contract Capacity per Day (Gallons).	Lift (Feet).
Deer Island station (Boston Harbor),	4	235,000,000	19
East Boston station,	4	235,000,000	19
Charlestown station,	3	104,000,000	{ 11 8
Alewife Brook station (Somerville),	3	22,000,000	

There were purchased for the operation of the pumping stations 6,955 tons of bituminous coal, the average prices of which, at the different stations, varied from \$8.21 to \$8.76 per gross ton for the coal in the bins.

The amount expended for the stations was \$162,714.79. The average cost per million gallons of sewage lifted per foot at the several stations was \$0.198, a decrease of 7 per cent from the cost of last year.

(3) SOUTH METROPOLITAN SEWERAGE SYSTEM — CONSTRUCTION.

The amount expended for construction on account of the South Metropolitan System during the past year was \$112,932.03.

On account of the difficulties experienced in carrying on the work of constructing the Wellesley Extension of the High-level sewer, which have been noted in previous reports, the appropriations for the work were found inadequate for its completion. The Board was, accordingly, given authority to expend the further sum of \$225,000 by the Legislature of 1919 and work has been continued during the year. Of the nine sections into which the work was divided six are wholly and one about half completed. Contracts have been made for the construction of the remainder of the sewer with the exception of one section.

The Board acquired by taking during the year easements in 1.846 acres of land in Dedham for the construction of the Wellesley Extension of the High-level sewer.

(4) SOUTH METROPOLITAN SEWERAGE SYSTEM — MAINTENANCE.

The entire cost of maintenance of the South Metropolitan System during the past year was \$143,336.83.

Sewers and Pumping Stations.

The metropolitan sewers in the South Metropolitan System, which comprise the old Charles River valley sewer and Neponset River valley sewer, as well as the new High-level sewer and extensions, have a total length of 49.545 miles, and with these are connected local sewers having a length of 666.43 miles, involving 46,928 connections.

The pumping stations operated for the South Metropolitan Sewerage System are as follows:—

	Number of Engines.	Contract Capacity per Day (Gallons).	Lift (Feet).
Ward Street station (Roxbury District),	2	100,000,000	45
Quincy station,	3	18,000,000	28
Quincy sewerage lifting station,	2	3,000,000	20

The sewage of two small areas in Dorchester and Milton, included in the Neponset River valley system, which are too low for sewage to be delivered into the High-level sewer by gravity, is, under an arrangement with the city of Boston, disposed of through the Boston Main Drainage Works at Moon Island. By this arrangement the Commission is relieved from the expense of providing extra pumping facilities.

A large part of the sewage of the South District is lifted into the High-level sewer at the Ward Street pumping station in Roxbury. Most of the sewage of the city of Quincy is pumped into the High-level sewer at Greenleaf Street near the Quincy pumping station. All of the sewage of the South District is screened at the Nut Island screen-house for the purpose of intercepting solid matter, and is thence discharged at the bottom of the harbor from the outfalls about a mile off the island.

The daily average amount of sewage thus discharged was 65,100,000 gallons, and the maximum discharge in a single day was 144,500,000 gallons. The increase in the daily average over last year was 8,900,000 gallons. The daily average discharge of sewage for each individual contributing sewage in the district was 160 gallons.

There were 2,903 gross tons of bituminous coal purchased at the two pumping stations and the Nut Island screen-house, the average

prices of which varied from \$7.95 to \$8.60 per gross ton for the coal in the bins.

The total amount expended for the operation of the stations was \$87,683.66.

VII. SEWERAGE WORKS — FINANCIAL STATEMENT.

The financial abstract of the receipts, expenditures, disbursements, assets and liabilities of the Metropolitan Water and Sewerage Board for the fiscal year of the Commonwealth ending with November 30, 1919, was, as stated in connection with the Water Works, presented to the General Court in January in accordance with the requirements of Chapter 235 of the Acts of the year 1906, and a copy of this financial abstract is in part printed as Appendix No. 5.

The following statement of its financial doings, in relation to the Metropolitan Sewerage Works, for the calendar year 1919 is herewith presented in accordance with the provisions of the Act of 1906.

(1) METROPOLITAN SEWERAGE LOANS, RECEIPTS AND PAYMENTS.

The loans authorized for the construction of the Metropolitan Sewerage Works, the receipts which are added to the proceeds of these loans, the expenditures for construction, and the balances available on January 1, 1920, have been as follows: —

North Metropolitan System.

Loans authorized under various acts to January 1, 1920, for the construction of the North Metropolitan System and the various extensions,	\$7,512,365 73
Receipts from sales of real estate and from miscellaneous sources which are placed to the credit of the North Metropolitan System: —	
For the year ending December 31, 1919,	\$212 03
For the period prior to January 1, 1919,	\$6,021 19
	<hr/>
	86,233 22
	<hr/>
	\$7,598,598 95
Amount approved for payment by the Board ¹ out of the Metropolitan Sewerage Loan Fund, North System: —	
For the year ending December 31, 1919,	\$112,531 93
For the period prior to January 1, 1919,	7,329,026 54
	<hr/>
	7,441,558 47
Balance, North Metropolitan System, January 1, 1920, . .	\$157,040 48

¹ The word "Board" refers to the Metropolitan Sewerage Commission and the Metropolitan Water and Sewerage Board.

South Metropolitan System.

Loans authorized under the various acts to January 1, 1920,
 applied to the construction of the Charles River valley
 sewer, Neponset valley sewer, High-level sewer and exten-
 sions, constituting the South Metropolitan System, . . . \$9,812,046 27

Receipts from pumping, sales of real estate and from miscella-
 neous sources, which are placed to the credit of the South
 Metropolitan System: —

For the year ending December 31, 1919, . . .	\$324 62	
For the period prior to January 1, 1919, . . .	19,415 03	
	<hr/>	19,739 65
		<hr/>
		\$9,831,785 92

Amount approved by the Board for payment out of the Met-
 ropolitan Sewerage Loan Fund, South System: —

On account of the Charles River valley sewer, . .	\$800,046 27
On account of the Neponset valley sewer, . . .	911,531 46
On account of the High-level sewer and exten- sions, including Wellesley extension: —	

For the year ending December

31, 1919,	\$112,932 03
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For the period prior to January

1, 1919,	7,767,746 79
	<hr/>
	7,880,678 82

	<hr/>	9,592,256 55
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Balance, South Metropolitan System, January 1, 1920, . .	\$239,529 37
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(2) TOTAL SEWERAGE DEBT, DECEMBER 31, 1919.

North Metropolitan System.

Bonds issued by the Treasurer of the Commonwealth:—

Sinking fund bonds (3 and 3½ per cent),	\$6,563,000 00
Serial bonds (3½ and 4 per cent),	925,500 00
<hr/>	
Total bond issue to December 31, 1919,	\$7,488,500 00
Serial bonds paid prior to January 1, 1919,	\$101,500 00
Serial bonds paid in 1919,	26,500 00
<hr/>	
	128,000 00

Total bond issue outstanding December 31, 1919, \$7,360,500 00

Gross sewerage debt,	\$7,360,500 00
Sinking fund December 31, 1919,	2,946,215 08
<hr/>	

Net sewerage debt December 31, 1919, \$4,414,284 92

A net decrease for the year of \$282,223.18.

South Metropolitan System.

Bonds issued by the Treasurer of the Commonwealth:—

Sinking fund bonds (3 and 3½ per cent),	\$8,877,912 00
Serial bonds (4 and 5 per cent),	720,000 00
<hr/>	
Total bond issue to December 31, 1919,	\$9,597,912 00
Serial bonds paid prior to January 1, 1919,	\$42,000 00
Serial bonds paid in 1919,	21,000 00
<hr/>	
	63,000 00

Total bond issue outstanding December 31, 1919, \$9,534,912 00

Gross sewerage debt,	\$9,534,912 00
Sinking fund December 31, 1919,	1,749,357 99
<hr/>	

Net sewerage debt December 31, 1919, \$7,785,554 01

A net decrease for the year of \$190,644.39.

(3) NORTH AND SOUTH METROPOLITAN LOAN AND SINKING FUNDS,
DECEMBER 31, 1919.

YEAR.	LOANS.		BONDS ISSUED (SINKING FUND).		BONDS ISSUED (SERIAL BONDS).		SINKING FUND.
	North System.	South System.	North System.	South System.	North System.	South System.	North and South Systems.
1889, . .	\$5,000,000 00	-	-	-	-	-	-
1890, . .	-	-	\$2,200,000	\$800,000	-	-	-
1891, . .	-	-	368,000	-	-	-	-
1892, . .	-	-	1,053,000	-	-	-	-
1893, . .	-	-	579,000	-	-	-	-
1894, . .	500,000 00	-	500,000	-	-	-	-
1895, . .	300,000 00	\$500,000 00	300,000	300,000	-	-	-
1896, . .	30,000 00	-	30,000	200,000	-	-	-
1897, . .	85,000 00	300,000 00	80,000	300,000	-	-	-
1898, . .	215,000 00	35,000 00	220,000	35,000	-	-	-
1899, . .	-	4,625,000 00	-	1,025,000	-	-	\$361,416 59
1900, . .	265,000 00	10,912 00 ¹	265,000	10,912	-	-	454,520 57
1901, . .	-	40,000 00	-	2,040,000	-	-	545,668 26
1902, . .	-	-	-	\$64,000	-	-	636,084 04
1903, . .	500,000 00	1,000,000 00	500,000	1,736,000	-	-	754,690 41
1904, . .	-	392,000 00	-	392,000	-	-	878,557 12
1905, . .	-	-	-	-	-	-	1,008,724 95
1906, . .	55,000 00	1,175,000 00	55,000	175,000	-	-	1,146,998 68
1907, . .	-	-	-	300,000	-	-	1,306,850 30
1908, . .	413,000 00	-	-	700,000	-	-	1,492,418 98
1909, . .	-	-	300,000	-	-	-	1,673,784 40
1910, . .	56,000 00	-	113,000	-	-	-	1,931,741 89
1911, . .	6,000 00	-	-	-	-	-	2,184,674 98
1912, . .	378,000 00	-	-	-	\$62,000	-	2,458,541 20
1913, . .	-	-	-	-	378,000	-	2,749,337 90
1914, . .	130,500 00	350,000 00	-	-	-	-	3,011,512 44
1915, . .	83,000 00	5,000 00	-	-	130,500	-	3,290,979 46
1916, . .	285,000 00	40,000 00	-	-	70,000	\$355,000	3,604,657 27
1917, . .	-	325,000 00	-	-	285,000	40,000	3,925,792 75
1918, . .	-	-	-	-	-	325,000	4,270,205 50
1919, . .	-	225,000 00	-	-	-	-	4,695,573 07
	\$8,301,500 00 ²	\$9,022,912 00	-	-	-	-	-
	789,134 27	789,134 27	-	-	-	-	-
	\$7,512,365 73	\$9,812,046 27	\$6,563,000	\$8,877,912	\$925,500	\$720,000	-

¹ The sum of \$10,912 was appropriated to reimburse the town of Watertown for the expense of constructing the Watertown siphon.

² Of this amount, \$789,134.27 was expended for the construction of the Charles River valley sewer, which is now included in the South Metropolitan System.

(4) ANNUAL APPROPRIATIONS, RECEIPTS AND EXPENDITURES.

The annual appropriations for the maintenance of the Metropolitan Sewerage Works, the receipts which are added to the appropriations for maintenance, and the expenditures for maintenance for the year ending December 31, 1919, were as follows:—

North Metropolitan System.

Appropriation as follows:—

Item 513, Chapter 153, Special Acts of 1919,	\$260,000 00
Receipts from pumping and from other sources,	2,076 66
	<hr/>
	\$262,076 66
Amount approved by the Board for payment,	234,588 14
	<hr/>
Balance January 1, 1920,	\$27,488 52

South Metropolitan System.

Appropriations as follows:—

Item 514, Chapter 153, Special Acts of 1919,	\$147,000 00
Item 514, Chapter 242, Special Acts of 1919,	5,000 00
Receipts from pumping and from other sources,	376 51
	<hr/>
	\$152,376 51
Amount approved by the Board for payment,	143,336 83
	<hr/>
Balance January 1, 1920,	\$9,039 68

(5) SEWER ASSESSMENTS, 1919.

The following sewer assessments were made by the Treasurer of the Commonwealth upon the various municipalities:—

North Metropolitan Sewerage System.

Sinking fund requirements,	\$125,355 09
Serial bonds,	24,000 00
Interest,	232,992 76
Maintenance:—	
Appropriated by Legislature,	\$260,000 00
Less balance on hand,	8,052 15
	<hr/>
	251,947 85
	<hr/>
Total North Metropolitan sewerage assessment,	\$634,295 70

South Metropolitan Sewerage System.

Sinking fund requirements,	\$90,426 14
Serial bonds,	21,000 00
Interest,	339,870 63
Maintenance:—	
Appropriated by Legislature,	\$152,000 00
Less balance on hand,	2,639 28
	<hr/> 149,360 72
Total South Metropolitan sewerage assessment,	\$600,657 49

In accordance with the provisions of Chapter 369, Acts of 1906, the proportion to be paid by each city and town to meet the interest and sinking fund requirements for each year is based upon their respective taxable valuations, and to meet the cost of maintenance and operation upon their respective populations.

The divisions of the assessments for 1919 were as follows:—

North Metropolitan Sewerage System.

CITIES AND TOWNS.	Assessment.	CITIES AND TOWNS.	Assessment.
Arlington,	\$18,507 75	Reading, ¹	\$5,046 99
Belmont,	11,366 29	Revere,	25,325 62
Boston,	98,845 50	Somerville,	88,244 86
Cambridge,	133,430 27	Stoneham,	7,137 93
Chelsea,	41,560 71	Wakefield,	13,573 05
Everett,	40,722 67	Winchester,	14,797 67
Lexington,	5,129 19	Winthrop,	15,191 94
Malden,	46,236 14	Woburn,	16,830 49
Medford,	33,634 25	Total,	<hr/> \$634,295 70
Melrose,	18,714 38		

¹ Reading is also assessed \$7,000 for sinking fund requirements in accordance with Section 5, Chapter 159, General Acts of 1916.

South Metropolitan Sewerage System.

CITIES AND TOWNS.	Assessment.	CITIES AND TOWNS.	Assessment.
Boston,	\$297,203 67	Quincy,	\$50,273 57
Brookline,	80,153 13	Waltham,	33,858 76
Dedham,	13,495 03	Watertown,	25,876 30
Milton,	17,262 17	Wellesley, ¹	11,101 90
Newton,	71,432 96	Total,	<hr/> \$600,657 49

¹ Wellesley is also assessed \$6,775.23 for sinking fund requirements in accordance with Section 5, Chapter 343, Acts of 1914.

(6) EXPENDITURES FOR THE DIFFERENT WORKS.

The following is a summary of the expenditures made in the various operations for the different works:—

CONSTRUCTION AND ACQUISITION OF WORKS.		For the Year ending December 31, 1919.
NORTH METROPOLITAN SYSTEM.		
North System, enlargement:—		
Administration,		\$3,885 82
Reading extension:—		
Section 73,	\$23,295 99	
Section 74,	22,571 06	
Section 75,	7,771 99	
Section 76,	53,962 62	
Real estate settlements,	250 00	
Legal, conveyancing and expert,	794 45	
		108,646 11
		\$112,531 93
Amount charged from beginning of work to January 1, 1919,		7,329,026 54
Total for North Metropolitan System to January 1, 1920,		\$7,441,558 47
SOUTH METROPOLITAN SYSTEM.		
High-level sewer extensions:—		
Administration,		\$3,826 47
Wellesley extension:—		
Section 98,	\$19,576 21	
Section 99,	77,878 73	
Section 100,	121 12	
Section 101,	556 66	
Section 103,	580 77	
Section 104,	538 04	
Section 105,	264 29	
Section 106,	10 40	
Real estate settlements,	8,975 00	
Legal, conveyancing and expert,	604 34	
		109,105 56
		\$112,932 03
Amount charged from beginning of work to January 1, 1919,		9,479,324 52
Total for South Metropolitan System to January 1, 1920,		\$9,592,256 55
Total for construction, both systems,		\$17,033,815 02
MAINTENANCE AND OPERATION.		For the Year ending December 31, 1919.
North Metropolitan System,		\$234,588 14
South Metropolitan System,		143,336 83
Total for maintenance, both systems,		\$377,924 97

(7) DETAILED FINANCIAL STATEMENT.

The Commissioner herewith presents, in accordance with the Metropolitan Sewerage acts, an abstract of the expenditures and disbursements, receipts, assets and liabilities for the year ending December 31, 1919:—

(a) *Expenditures and Disbursements.*

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1919.
CONSTRUCTION OF WORKS AND ACQUISITION BY PURCHASE OR TAKING. <i>North System Enlargement.</i>	
Administration:—	
Commissioners,	\$1,406 67
Secretary,	375 00
Clerks and stenographers,	1,541 49
Stationery, printing and office supplies,	217 68
Telephone, lighting, heating, water and care of building,	185 09
Rent and taxes, main office,	158 99
Miscellaneous expenses,	90
	\$3,885 82
Engineering:—	
Chief engineer,	\$833 34
Engineering assistants,	8,210 84
Inspectors,	323 00
Traveling expenses,	164 36
Stationery, printing and office supplies,	115 27
Engineering and draughting instruments and tools,	22 60
Engineering and draughting supplies,	54 10
Telephone, lighting, heating, water and care of building,	555 41
Rent and taxes,	477 00
Miscellaneous expenses,	159 75
	10,915 67
Construction:—	
Advertising,	\$122 85
Labor and teaming,	278 50
Brick, cement, lumber and other field supplies and expenses,	17,963 05
	18,364 40
Contracts:—	
Bruno & Petitti, Contract 144, for constructing a part of Section 76 of the Reading Extension of the North Metropolitan System in Wakefield and Reading,	\$48,886 54
Rendle-Stoddard Co., Contract 146, for constructing Section 73 of the Reading Extension of the North Metropolitan System in Woburn and Stoneham,	14,958 74
Rendle-Stoddard Co., Contract 148, for constructing Section 74 of the Reading Extension of the North Metropolitan System in Stoneham,	14,476 31
	78,321 59
Real estate:—	
Settlements,	\$250 00
Legal, conveyancing and expert,	794 45
	1,044 45
Total for North Metropolitan System,	\$112,531 93

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1919.
SOUTH METROPOLITAN SYSTEM. <i>High-level Sewer Extensions.</i>	
Administration: —	
Commissioners,	\$1,343 33
Secretary,	375 00
Clerks and stenographers,	1,567 74
Stationery, printing and office supplies,	184 17
Telephone, lighting, heating, water and care of building,	196 24
Rent and taxes, main office,	158 99
Miscellaneous expenses,	1 00
	\$3,826 47
Engineering: —	
Chief engineer,	\$625 00
Engineering assistants,	6,090 51
Inspectors,	2,360 65
Traveling expenses,	72 24
Engineering and drafting instruments and tools,	1 85
Stationery, printing and office supplies,	18 41
Engineering and drafting supplies,	94 80
Telephone, lighting, heating, water and care of building,	588 94
Rent and taxes, main office,	477 00
Miscellaneous expenses,	342 05
	10,671 45
Construction: —	
Advertising,	\$127 85
Labor and teaming,	6 00
Brick, cement, lumber and other field supplies and expenses,	576 91
	710 76
Contracts: —	
Rowe Contracting Co., Contract 139, for constructing Section 99 (in part) of the High-level sewer (Wellesley Extension) in Dedham,	\$69,096 95
John P. Cavanagh Co., Contract 149, for constructing Section 99 (in part) of the High-level sewer (Wellesley Extension) in Dedham,	901 00
George M. Bryne, under agreement dated October 23, 1916, for construct- ing Section 98 of the High-level sewer (Wellesley Extension) in West Roxbury and Dedham,	18,146 06
	88,144 01
Real estate: —	
Legal, conveyancing and expert,	\$604 34
Settlements,	8,975 00
	9,579 34
Total for South Metropolitan System,	\$112,932 03

GENERAL CHARACTER OF EXPENDITURES.		For the Year ending December 31, 1919.
MAINTENANCE AND OPERATION OF WORKS. <i>North Metropolitan System.</i>		
Administration: —		
Commissioners,	\$1,916 67	
Secretary and assistants,	2,850 95	
Rent,	238 50	
Heating, lighting and care of building,	262 32	
Postage,	38 00	
Printing, stationery and office supplies,	398 94	
Telephones,	45 65	
Traveling expenses,	20 00	
Miscellaneous expenses,	45 95	
		\$5,816 98
General supervision: —		
Chief engineer and assistants,	\$6,930 52	
Rent,	715 50	
Heating, lighting and care of building,	787 24	
Printing, stationery and office supplies,	258 40	
Telephones,	136 97	
Traveling expenses,	247 16	
Miscellaneous expenses,	27 32	
		9,103 11
Deer Island pumping station: —		
Labor,	\$25,356 16	
Fuel,	17,958 82	
Oil and waste,	1,323 22	
Water,	1,431 60	
Packing,	212 25	
Repairs and renewals,	1,633 44	
Telephones,	43 45	
General supplies,	846 43	
Miscellaneous supplies and expenses,	551 19	
		49,356 56
East Boston pumping station: —		
Labor,	\$29,879 51	
Fuel,	24,586 35	
Oil and waste,	1,150 81	
Water,	1,830 00	
Packing,	152 44	
Repairs and renewals,	2,656 50	
Telephones,	1 68	
General supplies,	1,133 72	
Miscellaneous supplies and expenses,	622 88	
		62,013 89
Charlestown pumping station: —		
Labor,	\$20,731 76	
Fuel,	10,534 40	
Oil and waste,	438 60	
Water,	661 20	
Packing,	25 60	
Amounts carried forward,	\$32,411 56	\$126,290 54

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1919.	
<i>Amounts brought forward,</i>	\$32,411 56	\$126,290 54
<i>North Metropolitan System — Con.</i>		
Charlestown pumping station — <i>Con.</i>		
Repairs and renewals,	730 36	
Telephones,	49 16	
General supplies,	320 41	
Miscellaneous supplies and expenses,	158 90	
		33,670 39
Alewife Brook pumping station: —		
Labor,	\$10,460 47	
Fuel,	5,693 60	
Oil and waste,	500 64	
Water,	299 04	
Packing,	57 55	
Repairs and renewals,	319 56	
Telephones,	39 08	
General supplies,	174 17	
Miscellaneous supplies and expenses,	129 84	
		17,673 95
Sewer lines, buildings and grounds: —		
Engineering assistants,	\$2,183 52	
Labor,	36,298 06	
Automobiles,	817 09	
Brick, cement and lime,	603 96	
Castings, ironwork and metals,	1,042 26	
Freight, express and teaming,	4 49	
Fuel and lighting,	71 21	
Jobbing and repairing,	254 07	
Lumber,	2,384 51	
Machinery, tools and appliances,	1,395 46	
Paints and oils,	1,174 80	
Rubber and oiled goods,	187 73	
Sand, gravel and stone,	82 49	
Telephones,	94 21	
Traveling expenses,	892 57	
General supplies,	1,539 19	
Miscellaneous expenses,	189 71	
		49,215 33
Horses, vehicles and stable account,		4,822 02
Payments under Industrial Accident Law and special benefit appropriations,		2,915 91
Total for North Metropolitan System,		\$234,588 14

GENERAL CHARACTER OF EXPENDITURES.		For the Year ending December 31, 1919.
<i>South Metropolitan System.</i>		
Administration: —		
Commissioners,	\$1,916 66	
Secretary and assistants,	2,239 92	
Rent,	206 70	
Heating, lighting and care of building,	246 97	
Postage,	20 00	
Printing, stationery and office supplies,	331 40	
Telephones,	29 58	
Traveling expenses,	51 65	
Miscellaneous expenses,	49 80	
		\$5,092 63
General supervision: —		
Chief engineer and assistants,	\$4,852 70	
Rent,	620 10	
Heating, lighting and care of building,	740 98	
Printing, stationery and office supplies,	119 98	
Telephones,	88 76	
Traveling expenses,	212 24	
Miscellaneous expenses,	22 13	
		6,656 89
Ward Street pumping station: —		
Labor,	\$31,176 53	
Fuel,	16,826 84	
Oil and waste,	484 90	
Water,	1,795 20	
Packing,	2 30	
Repairs and renewals,	4,512 57	
Telephones,	50 69	
General supplies,	1,514 32	
Miscellaneous supplies and expenses,	786 75	
		57,150 10
Quincy pumping station: —		
Labor,	\$10,303 95	
Fuel,	2,949 24	
Oil and waste,	150 48	
Water,	320 42	
Packing,	74 73	
Repairs and renewals,	477 10	
Telephones,	37 16	
General supplies,	476 76	
Miscellaneous supplies and expenses,	288 63	
		15,078 47
Nut Island screen-house: —		
Labor,	\$10,520 60	
Fuel,	2,994 10	
Oil and waste,	180 67	
Water,	314 82	
Packing,	21 21	
Amounts carried forward,	\$14,031 40	\$83,978 14

GENERAL CHARACTER OF EXPENDITURES.	For the year ending December 31, 1919.	
<i>Amounts brought forward,</i>	\$14,031 40	\$83,978 14
<i>South Metropolitan System — Con.</i>		
Nut Island screen-house — <i>Con.</i>		
Repairs and renewals,	214 91	
Telephones,	49 80	
General supplies,	895 53	
Miscellaneous supplies and expenses,	263 45	
		15,455 09
Sewer lines, buildings and grounds: —		
Engineering assistants,	\$4,760 85	
Labor,	23,616 17	
Automobiles,	1,133 17	
Brick, cement and lime,	103 04	
Castings, ironwork and metals,	216 18	
Fuel and lighting,	21 70	
Freight, express and teaming,	1 45	
Jobbing and repairing,	13 25	
Lumber,	832 51	
Machinery, tools and appliances,	851 81	
Paints and oils,	205 18	
Rubber and oiled goods,	29 45	
Sand, gravel and stone,	44 00	
Telephones,	39 81	
Traveling expenses,	1,089 02	
General supplies,	684 88	
Miscellaneous expenses,	111 82	
		33,754 29
City of Boston for pumping,		5,869 36
Horses, vehicles and stable account,		3,746 95
Payments under Industrial Accident Law and special benefit appropriations,		533 00
Total for South Metropolitan System,		\$143,336 83

(b) Receipts.

The receipts from the sales of property, from rents and from other sources, have been credited as follows:—

ACCOUNT.	For the Year ending December 31, 1919.
Construction:—	
North Metropolitan System,	\$212 03
South Metropolitan System,	324 62
Maintenance:—	
North Metropolitan System,	2,076 66
South Metropolitan System,	376 51
Sinking fund:—	
North Metropolitan System,	99 96
Interest fund:—	
North Metropolitan System,	67 51
South Metropolitan System,	44 50
Amount credited from beginning of work to January 1, 1919,	\$3,201 79
	150,663 77
Total receipts to January 1, 1920,	\$153,865 56

(c) Assets.

The following is an abstract of the assets of the Sewerage Works, a complete schedule of which is kept on file in the office of the Commission:—

Office furniture, fixtures and supplies; engineering and scientific instruments and supplies; horses, vehicles, field machinery, etc.; machinery, tools and other appliances and supplies; completed works, real estate connected therewith.

(d) Liabilities.

There are sundry bills for current expenses which have not yet been received.

Amounts on Monthly Estimates, not due until Completion of Contracts or until Claims are settled.

NAME.	Work.	Amount.
North System enlargement:—		
Rendle-Stoddard Co.,	Contract 146, Section 73, Reading Extension, . .	\$2,639 77
Rendle-Stoddard Co.,	Contract 148, Section 74, Reading Extension, . .	2,554 64
High-level sewer extensions:—		
Timothy O'Connell,	Contract 57, Section 82 (in part),	60 00
Rowe Contracting Co.,	Contract 139, Section 99 (in part), Wellesley Extension.	2,500 00
John P. Cavanagh Co.,	Contract 149, Section 99 (in part), Wellesley Extension.	159 00

Settlements are pending with the following parties for easements taken in lands owned by them:—

Clifford M. Locke, Martha W. Burrage, Edward and Catherine Bingham, Katherine H. Rooney, Mary A. Read, Hannah E. Pond, Richard G. Wadsworth, Frank D. Chase, Devises of Anna E. Chase, Stephen M. Weld, Lucia Beebe, Edward F. Gilman, Herbert M. Hopkins, Joseph E. Hopkins, George A. Forbes, Bear Hill Associates, Lawrence Minot and Moses Williams, Trustees, Frederick P. Royce and Francis Peabody, Trustees, Bessie C. Olson, William B. and Helen B. Stevens, Stella Gilker, Maurice McKenna, Michael Flynn, Sarah A. Brown, John B. Tidd, George A. Owen and George E. Merrifield, Mary A. Scally, Stoneham Branch Railroad.

VIII. RECOMMENDATIONS FOR LEGISLATION.

In the abstract of the annual report for the year 1919 the following statement and recommendations were made:—

Attention has been called in previous reports to certain large expenditures in connection with some inevitable improvements and extensions of the Metropolitan Water System.

The plan submitted by the State Board of Health in 1895, and accepted by the Legislature of the same year, showed a direct line of communication between the proposed line to Weston and Spot Pond. As this connection could be avoided by pumping the Spot Pond supply from the Chestnut Hill reservoirs for a number of years, the question has not hitherto been brought definitely before the Legislature, but in order to furnish reliable and satisfactory service in the future under conditions which prevail at times of maximum consumption, it now seems advisable to provide for the construction of a large supply main from the Weston Aqueduct to the northern portion of the District, the supply of which would be seriously impaired by failure from any cause to operate the pumps at the Chestnut Hill stations.

The estimated cost of this supply main from the terminal chamber of the Weston Aqueduct through Waltham to Arlington Centre and connecting with the two existing 30-inch mains at the old Mystic pumping station in Somerville is \$1,800,000, or about three times the cost of a similar pipe line before the war. About two-thirds of the cost is for material and one-third for labor. It is recommended that authority be given to construct this pipe line, in order that the more necessary portions can be undertaken at an early date.

The Arlington standpipe, built by the town of Arlington in 1894, was acquired by the Metropolitan Water Works in January, 1899, and is now used as a reservoir to regulate the water pressure in Lexington and portions of Arlington and Belmont. As the standpipe was not constructed with a view to supplying the district beyond the boundaries of the town of Arlington, it has now become inadequate for such use and should be replaced by a larger structure, similar

to that erected on Mt. Bellevue in West Roxbury for the southern extra high-service district, as proposed last year, and the recommendation is renewed that an appropriation of \$175,000 be authorized for this purpose.

The machinery at the Spot Pond pumping station includes three vertical fire tube boilers installed in 1899, a 300-horse-power vertical independent compound engine and a vertical triple expansion engine, which were installed in 1900.

The consumption of water in the northern high-service district has greatly increased since the pumping machinery at the Spot Pond station was installed and during periods of high consumption now exceeds the capacity of the compound engine, with which the supply is maintained when the other engine is out of service for any reason. To provide satisfactory service the installation of new machinery should be undertaken as soon as possible and it is recommended that an appropriation of \$250,000 be authorized for this purpose.

At the Chestnut Hill pumping stations there is one boiler over 20 years old and three others that will be 20 years old next year. There are also three boilers on which the allowed pressure has been reduced below the point where they can be satisfactorily used to operate the engines.

The two horizontal compound duplex engines installed at this station in 1887 have been in service for 31 years, are now worn out and should be replaced with modern high duty engines. To provide for this new southern high-service pumping machinery, it is recommended that an appropriation of \$200,000 be authorized so that the work can be begun next year.

The portion of the cities of Somerville, Malden and Medford supplied from the northern high-service works are now entirely dependent upon a single pipe line of inadequate capacity at times of maximum consumption. To remedy this condition and provide reliable and satisfactory service it is recommended that an appropriation of \$280,000 be authorized for an additional northern high-service pipe line.

On account of the large amount of ground water and greasy mill wastes which now enter the Clinton sewers, the existing filtration area, which is capable of properly purifying only 750,000 gallons per day of ordinary sewage, is overloaded with more than 1,000,000 gallons per day of greasy sewage which cannot be properly purified with the existing works. If existing conditions are to continue it is recommended that an appropriation of \$60,000 be authorized for enlarging the Clinton sewerage works to meet the requirements of the situation.

It is accordingly recommended that authority be given for additional water loans, to be issued from time to time as may be required for the above purposes, to a total amount not exceeding \$2,765,000, to be apportioned to the different works as follows: —

Reinforcement of low-service pipe line,	\$1,800,000
Northern extra high-service reservoir,	175,000
Northern high-service pumping machinery,	250,000
Southern high-service pumping machinery,	200,000
Reinforcement of northern high-service pipe lines,	280,000
Clinton sewerage,	60,000
Total,	\$2,765,000

The rapid growth in the population of the city of Quincy has made it necessary that additional plant and other changes shall be introduced at the Quincy pumping station. At the present time this station has a 3,000,000 gallon Dean pump, a 5,000,000 gallon pump of similar type and a 10,000,000 gallon centrifugal pump. During the greater part of the year it is necessary to run the two smaller pumps together. At no time can the smallest pump take care of the daily flow. It is deemed advisable to install a larger pump in place of the 3,000,000 gallon pump. For this purpose it is recommended that an appropriation of \$10,000 be authorized.

The screening apparatus at this station is very crude in design and is entirely inadequate for present needs. It is recommended that an appropriation of \$3,000 be authorized for new screening machinery. The water for condensation purposes is at present taken from ground wells. These are inadequate and provision should be made for the construction of a reservoir which would be filled at high tide and contain a sufficient supply to last through the succeeding twelve hours. For this purpose it is recommended that an appropriation of \$2,000 be authorized.

It is recommended that authority be given for additional Metropolitan Sewerage Loan bonds to an amount not exceeding \$15,000, to be expended in making the changes and improvements at the Quincy station as outlined above.

The detailed reports of the Chief Engineer of Water Works and the Chief Engineer of Sewerage Works, with various tables and statistics, are herewith presented.

Respectfully submitted,

JAMES A. BAILEY,
Metropolitan District Commissioner.

Boston, February 27, 1920.

REPORT OF DIRECTOR AND CHIEF ENGINEER OF WATER DIVISION.

JAMES A. BAILEY, *Commissioner, Metropolitan District Commission.*

SIR:—I have the honor to submit the following report of the construction and maintenance operations on the Metropolitan Water Works for the calendar year 1919.

ORGANIZATION.

Mr. Charles E. Haberstroh was retired February 12 after a long and creditable service in connection with the Sudbury Works, having previously served with the city of Boston from 1875 to 1898, when the works were taken by the Commonwealth.

Mr. Frank S. Hart, who has been connected with the Sudbury Works since 1891, was appointed Superintendent upon the retirement of Mr. Haberstroh on February 12 and since then the organization has been as follows:—

John L. Howard,	. . .	Assistant to Chief Engineer.
Elliot R. B. Allardice,	. . .	Superintendent of Wachusett Department.
Frank S. Hart,	. . .	Superintendent of Sudbury Department.
Samuel E. Killam,	. . .	Superintendent of Distribution Pipe Lines and Reservoirs.
Arthur E. O'Neil,	. . .	Superintendent of Distribution Pumping Stations.
Alfred O. Doane,	. . .	Division Engineer, in charge of Mechanical Engineering and Inspection Work.
William W. Locke,	. . .	Sanitary Inspector, in charge of Sanitary Inspection of Watersheds.
Clifford Foss,	. . .	Assistant Engineer, in charge of Distribution Civil Engineering.
Benjamin F. Hancox,	. . .	Head Draftsman, in charge of Drafting Force.
James W. Killam,	. . .	Assistant Engineer, in charge of Coal and Oil Laboratory and compilation of Pumping Statistics.
William E. Whittaker,	. . .	Office Assistant, in charge of General Office and compilation of Water Supply Statistics.
Charles E. Livermore,	. . .	Biologist, in charge of Microscopical and Bacteriological Examinations of the Water Supply.

Including these principal assistants the number of supervising, engineering and clerical employees was 42 at the beginning of the year and 44 at the end of the year.

In addition to the office forces the labor forces engaged in maintaining and operating the reservoirs, aqueducts, pipe lines, hydro-electric stations and pumping stations and doing minor construction work have been as follows:—

DEPARTMENT.	Beginning of Year.	End of Year.	Maximum.	Average.
Wachusett,	41	50	82	61
Sudbury,	62	68	75	66
Distribution, pipe lines and reservoirs, . . .	82	93	102	91
Distribution, pumping service,	70	74	75	71
	255	285	334	289

CONSTRUCTION.

METERS AND CONNECTIONS.

The work of relocating Venturi meters and of making additional connections under the provisions of chapter 172 of the General Acts of 1916 on the pipe lines acquired from the city of Boston in 1913, which was suspended during 1918 because of the shortage of labor, was resumed May 19 on the low-service mains in Washington Street, Brookline.

The work of setting the meter in the 30-inch main was completed June 5. Work was then begun on the 36-inch and 40-inch mains, but on account of heavy street traffic and numerous underground structures the work was difficult and the progress slow, and at the end of the year the work is not entirely finished, as the meter registers have not been installed and only temporary street repairs have been made.

In connection with this work the 30-inch main was out of service from May 26 to June 5, the 40-inch main from August 2 to October 3 and the 36-inch main from October 3 to December 9. The work included the setting of one 30-inch and one 36-inch Venturi meter, one 24-inch and two 36-inch gate valves and one 30-inch and one 36-inch check valve, and the laying of 52.3 feet of 30-inch, 207.7 feet of 36-inch and 10 feet of 40-inch water pipe, including curves, branches, manhole pipes and other special castings.

Expenditures for this year's work amount to \$13,018.34 and the total expenditures for meters and connections under chapter 172 of the General Acts of 1916 to December 31, 1919, are \$35,447.95.

ADDITIONAL 36-INCH LOW-SERVICE PIPE LINE FOR EAST BOSTON.

The pipes and special castings required for constructing the additional 36-inch low-service pipe line for East Boston, which was authorized by chapter 322 of the General Acts of 1917 and chapter 166 of the General Acts of 1919, were purchased from the Warren Foundry & Machine Company at a price of \$42.75 per ton for the pipes and \$100 per ton for the specials on the cars at the foundry, and freight charges of \$4.10 per ton were paid for transportation.

The contract for laying the pipes was made with Coleman Brothers of Chelsea August 14. The pipe line is 1,689 feet in length and extends from the 42-inch pipe line in Broadway near Second Street to the 36-inch pipe line in Essex Street at Shawmut Street in Chelsea. Contract work was begun August 25 and completed November 28. The new pipe line was connected with the distribution system by the regular water works employees and put into service December 18. The expenditures for this pipe line amount to \$29,536.91.

NORTHERN EXTRA HIGH-SERVICE 16-INCH PIPE LINE FOR LEXINGTON.

The pipes and special castings for the northern extra high-service 16-inch pipe line for Lexington, which was authorized by chapter 172 of the General Acts of 1916 and chapter 167 of the General Acts of 1919, were purchased from the Warren Foundry & Machine Company at a price of \$42.75 per ton for the pipes and \$100 per ton for the specials on the cars at the foundry, and freight charges of \$4.10 per ton were paid for transportation.

The contract for laying the pipes was made with James Barletta of Boston August 14. The pipe line is 5,944 feet in length and extends from the standpipe on Park Avenue in Arlington to the Lexington boundary line at Massachusetts Avenue. Near both ends of the line the pipe trench was located partly in rock, of which 880 cubic yards were excavated. Contract work was begun September 4 and completed December 16, when 5,740 feet of pipe had been laid by the contractor. The trench for the remaining 204 feet of pipe line near the standpipe had been excavated by the contractor, but on account of delay in receiving the pipes from the foundry they will

be laid by the regular water works employees when the new line is connected to the distribution system early in 1920. The expenditures for this pipe line amount to \$35,186.19.

SOUTHERN EXTRA HIGH-SERVICE 12-INCH PIPE LINE FOR HYDE PARK AND MILTON.

The construction of the southern extra high-service 12-inch pipe lines in Poplar Street, West Roxbury, and across the Neponset River at West Street, for Hyde Park and Milton were authorized by chapter 172 of the General Acts of 1916 and chapter 165 of the General Acts of 1919. The flexible jointed pipes for the duplicate pipe line which is to be laid under the Neponset River parallel with the existing line were received late in 1918, but on account of shortage of labor and unfavorable weather they have not yet been laid. The pipes and special castings for the pipe line in Poplar Street were purchased of the Warren Foundry & Machine Company at a price of \$42.75 per ton for the pipes and \$100 per ton for the specials on cars at the foundry, and freight charges of \$4.10 per ton were paid for transportation.

The contract for laying the pipe in Poplar Street was made with Vincenzo Grande of Boston August 13. The pipe line is 2,107 feet in length and is parallel with a 12-inch pipe line owned by the city of Boston which has been used jointly with the Commonwealth since 1902. The contractor began work October 2 and on November 22 had completed everything except the final resurfacing of the street, which it was necessary to defer until spring on account of unfavorable weather. The new pipe line will be connected with the distribution system by the regular water works employees early in 1920.

The expenditures amount to \$2,983.33 for the river crossing and to \$8,853.32 for the Poplar Street line.

MAINTENANCE.

RAINFALL AND YIELD OF WATERSHEDS.

The annual precipitation on the watersheds was above the average during 1919, being 49.05 inches on the Wachusett watershed, 45.64 inches on the Sudbury and 46.07 inches on the Cochituate watershed. The monthly precipitation was noticeably above normal in May, September and November and noticeably below normal in June, October and December.

The percentage of rainfall collected was 53.8 on the Wachusett, 45.5 on the Sudbury and 48.1 on the Cochituate watershed.

The annual yield of the watersheds was above the average during 1919, the amount in gallons per day per square mile being 1,257,000 on the Wachusett, 988,000 on the Sudbury and 1,056,000 on the Cochituate. The monthly yield was noticeably above normal in May, September and November and noticeably below normal in February.

Between June 15 and December 15 the city of Worcester discharged 343,200,000 gallons of water into the Wachusett Reservoir watershed from the 9.35 square miles formerly tributary to the reservoir and which the city diverted for its water supply in 1911. In accordance with the agreement of November 2, 1914, the city will be paid at the rate of \$2 per million gallons for this water by the Commonwealth. The city also discharged 1,864,800,000 gallons of water from the diverted area into the Wachusett Reservoir watershed at other times during the year for which no compensation will be paid as the reservoir filled before June 15.

STORAGE RESERVOIRS.

The capacities of the storage reservoirs of the Metropolitan Water Works, the elevation of the water surfaces and the quantity of water stored in each reservoir at the beginning and at the end of the year are shown by the following table:—

STORAGE RESERVOIRS.	Elevation ¹ of High Water.	Capacity (Gallons).	JAN. 1, 1919.		JAN. 1, 1920.	
			Elevation ¹ of Water Surface.	Amount stored (Gallons).	Elevation ¹ of Water Surface.	Amount stored (Gallons).
Cochituate watershed:—						
Lake Cochituate, ² . . .	144.36	2,097,100,000	142.91	1,755,400,000	143.96	2,002,100,000
Sudbury watershed:—						
Sudbury Reservoir, . . .	260.00	7,253,500,000	258.24	6,520,600,000	258.01	6,425,900,000
Framingham Reservoir	169.32	289,900,000 ³	167.87	223,400,000	167.85	222,600,000
No. 1.						
Framingham Reservoir	177.87	529,900,000 ³	176.20	490,300,000	176.08	485,200,000
No. 2.						
Framingham Reservoir	186.74	1,180,000,000 ³	185.09	1,066,200,000	186.84	1,207,900,000
No. 3.						
Ashland Reservoir, . . .	225.21	1,416,400,000	224.50	1,377,300,000	224.42	1,372,900,000
Hopkinton Reservoir, . .	305.00	1,520,900,000	304.18	1,469,600,000	304.06	1,462,100,000
Whitehall Reservoir, . .	337.91	1,256,900,000	336.90	1,061,100,000	336.65	1,013,300,000
Farm Pond,	159.25	167,500,000	158.12	107,500,000	158.40	122,200,000
Wachusett watershed:—						
Wachusett Reservoir, . .	395.00	64,968,000,000	381.88	48,426,600,000	392.03	61,013,500,000
Totals,	—	80,680,100,000	—	62,498,000,000	—	75,327,700,000

¹ Elevation in feet above Boston City Base.

³ To top of flash-boards.

² Excluding Dudley Pond which was abandoned April 3, 1916.

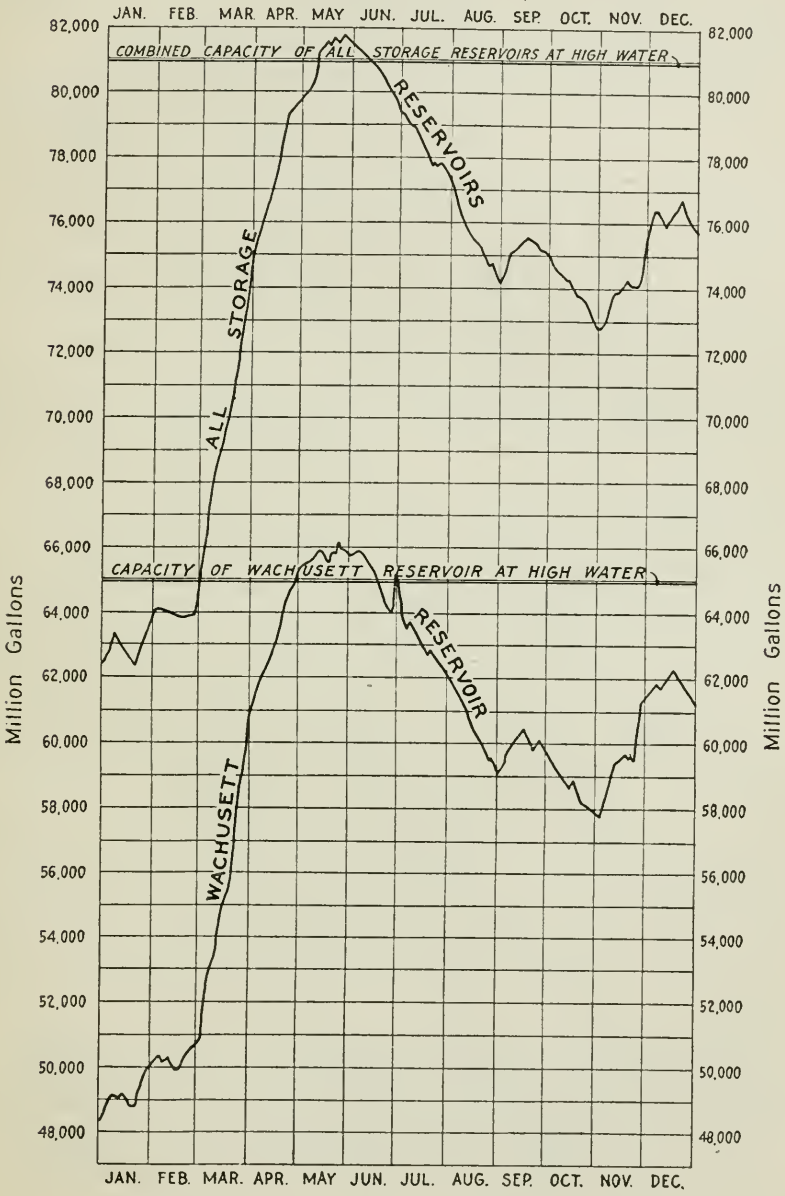
The diagram on page 51 shows the quantity of water stored in the Wachusett Reservoir and the quantity stored in all the storage reservoirs combined during the year.

The table and diagram show the total storage which could be drained from the reservoirs. Special provisions would be necessary, however, to draw about 10,000,000,000 gallons of this storage for consumption as it is below the outlet channels which can be conveniently used for regular service.

Wachusett Reservoir.

The water in the Wachusett Reservoir was 13.12 feet below ordinary high-water line at the beginning of the year, the amount in storage being 48,426,600,000 gallons. The water rose about 2 feet during January and February and with the spring rains and thaws which followed the reservoir had filled to high-water line, or elevation 395, on April 26. The water remained above this elevation until June 16. The highest stage reached was elevation 395.93 on May 23, and the reservoir then contained 66,226,100,000 gallons of water. Between May 10 and June 1, 3,170,000,000 gallons of water were wasted from the reservoir at the overflow as the New England Power Company was unable to take additional power at that time without wasting water at its plants. The maximum rate of waste at the overflow was 692,000,000 gallons per day on May 23. From June 1 to September 1 the water in the reservoir was drawn down at the rate of about 1.75 feet per month; it then rose nearly one foot during the early part of September and then receded at the rate of about one foot per month until November 1 when it was 5.41 feet below high-water line. After November 1 the water rose continuously and at times rapidly, due to heavy rains, until December 3 when elevation 392.52 was reached. On account of the high stage of the water for that time of the year and the abundant yield it was deemed advisable to waste water from the reservoir in order to reserve storage capacity for use in regulating the freshet flows next spring and to conserve the water power which could be disposed of then but probably could not be utilized next spring when the New England Power Company would be wasting water at its plants. Between December 3 and December 16 the precipitation amounted to nearly 2 inches and the water in the reservoir rose to elevation 393.10 notwithstanding the increased draft which had been maintained since

QUANTITY OF WATER STORED IN THE WACHUSETT RESERVOIR
AND IN ALL THE STORAGE RESERVOIRS COMBINED
DURING 1919



December 3, and on account of the continued large yield of the watershed water was wasted at an increased rate from the reservoir until the end of the year when the water in the reservoir stood at elevation 392.03, which is higher than at the close of any previous year, and the amount in storage was 61,013,500,000 gallons.

From December 3 to the end of the year 2,177,300,000 gallons of water in excess of the amount required for consumption were drawn from the reservoir and wasted, but by utilizing the Sudbury power station and the head gates installed at the entrance to the Wachusett Aqueduct in 1918 all of the water was used for generating electric energy, which was sold at the regular contract prices for the sum of \$3,114.18, while the quality of the water delivered for consumption has been materially improved as a result of the operation. The amount of the waste water which was utilized for the generation of electric energy at the Wachusett power station only and was discharged into the Nashua River is 1,215,900,000 gallons. The maximum rate of waste into the river was 128,000,000 gallons per day.

In addition to the waste from the reservoir at the overflow and through the power station during the year 587,400,000 gallons of water have been discharged from the reservoir in accordance with the provisions of chapter 488 of the Acts of 1895. This is 499,800,000 gallons less for this purpose than during 1918. The reduction is due to improvements made at the Lancaster Mills in September, 1918, as a result of suggestions made to the mill officials at that time.

The southerly shore of the reservoir at the South Dike and Hastings Cove and the northerly shore at Kendall Cove were faced with heavy riprap to prevent further erosion by wave action and protect the highway embankment at the dike and the white pine plantings at the coves. The material used for this work was obtained from old stone walls and was placed along the shore line for a distance of 1,185 feet. The riprap varied from 8 to 22 feet in width, covered an area of 1,656 square yards and cost about 78 cents per square yard.

At several places on the southerly shore of the reservoir between Hastings Cove and Pine Hill, where the waves had undermined the slopes, the trees and bushes were cut and the roots and stumps grubbed for a distance of 35 to 50 feet back from the top of the slope and for a length of 4,090 feet. This work covered an area of $3\frac{2}{3}$ acres and cost \$173 per acre. In connection with this work

it was not deemed necessary to strip off the soil, as had been done in former years, which would have caused an additional expense of about \$500 per acre.

Material which drifted into the reservoir and was deposited along the shores at high water was removed at a cost of \$235.17. Brush and weeds were mowed and burned along the sides of the highways adjoining reservoir lands, along the brooks which flow directly into the reservoir and along the dikes. This work extended over a distance of 31 miles and cost \$2,726.39.

Wire fences have been erected along property lines and highways for a distance of 4,364 feet to keep cattle out of the water and from damaging the water works land. Standing grass was sold at auction on 367 acres of water works land for \$3,255.50.

The Wachusett Dam and adjacent structures and grounds have been given the usual care and for the most part are in good condition, but the granolithic walk on the dam, the planking in the bridge at the waste-weir and the roof of the gate chamber and of the power house need to be repaired.

The houses on the reservoir lands and the barns and other buildings located at these premises and at the Clinton and Oakdale storage yards have been kept in good condition. The interior of the house at the Kendall place in Boylston was renovated at a cost of \$354.29. The work included papering and painting and repairing floors and heater. The interior of the house at the Howe place in Sterling Junction was thoroughly renovated; the barn was remodelled and shingled, the hen house relocated and a new cesspool was constructed. The cost of this work was \$457.70. The sanitary conditions at this place have been very much improved. At the March place in Oakdale the water supply has been improved by installing an electric pump and storage tank; a bath room has been provided and arrangements have been made for heating the garage. The expenditures for this work amount to \$846.93. At the Cook place in West Boylston some of the rooms were renovated, a corner of the barn has been made into a workshop of sufficient capacity for a large auto truck and, including the cost of a chimney, the work cost \$392.51. At the Clinton storage yard the driveway was underdrained, graded and surfaced at a cost of \$476.08, and the floor of the carpenter shop was repaired at a cost of \$89.17.

Sudbury Reservoir.

The water in the Sudbury Reservoir was 0.76 of a foot below the crest of the overflow at the beginning of the year and was allowed to recede until it was 2.34 feet below the crest on February 26 in order to conserve power following an accident to the hydroelectric machinery at the Wachusett power station on February 17. The flash-boards were put on the overflow April 18 and the water was allowed to rise until it was 1.25 feet above the crest on June 5. Water overflowed from the Sudbury Reservoir into Framingham Reservoir No. 3 on 16 days. The overflow amounted to about 300,000,000 gallons. At other times all of the water flowing from the reservoir was used to generate electricity. With the exception of the water obtained from Framingham Reservoir No. 3 watershed and 713,900,000 gallons drawn from Lake Cochituate all of the water for consumption was drawn from the Sudbury Reservoir, which was replenished with water from the Wachusett Reservoir as required. The flash-boards were removed from the overflow November 21 and at the end of the year the water was 0.99 of a foot below the crest of the overflow.

The lands and structures at the reservoir have received the usual care. About 10 tons of hay were cut and stored in the water works barns. The shores of the reservoir were cleaned and the débris burned. The roads and walks were kept in repair and shrubs and trees were pruned.

The house, barn, storehouse, flash-boards and standards at the dam and the life preservers and holders were painted. New oak floors 3 inches thick were put in three stalls at the barn and a new garage was made of a portion of the storehouse. At the Cratty house in Fayville board ceiling was put in one room and three rooms were painted and papered.

A channel was cut in the ice back of the overflow at the dam during the winter as usual, to remove the ice pressure.

Sprouts and brush were cut and burned in the lanes and along the property lines for a distance of $3\frac{1}{4}$ miles. At some places where small pines had been set out the lanes were increased from 5 feet to 40 feet in width for fire guards and at other places the brush between clearings and property lines was cut out to a width of 10 feet. This work cost \$216.03.

Framingham Reservoir No. 3.

All of the water supplied through the Sudbury Aqueduct to the Metropolitan Water District and to the town of Framingham was drawn from Framingham Reservoir No. 3, which was replenished with water from the Sudbury Reservoir as required. The flow in the Sudbury Aqueduct is usually continuous day and night, but there is usually no flow from the Sudbury Reservoir into Framingham Reservoir No. 3 on Sundays or holidays and during about 8 hours on other days as the Sudbury power station is not then in operation. As a result there is considerable variation in the level of the water in Framingham Reservoir No. 3, which is also subject to further variation at times from the natural yield of its tributary drainage area. When the water in the reservoir is low the full capacity of the Sudbury Aqueduct cannot be utilized on account of the restricted capacity of the outlet pipes. The flash-boards were kept on the overflow all the year and the elevation of the water in the reservoir varied from 182.53 to 186.84. About 1,046,000,000 gallons of water were wasted from the reservoir during the year.

The gate-house, embankments, shrubs and grounds at the dam were given the usual care and the boat was painted. Sprouts and brush were cut along the east shore of the reservoir from the dam to Estabrook's land, along the south and west shore from Worcester Street to Buck's land, and in the lanes along the property lines for a distance of $2\frac{1}{2}$ miles and a width of 5 feet.

Wire was strung on fence posts previously set along the northerly boundary of the water works land at the upper end of the reservoir from the Stensson land to Boston Road, a distance of 3,070 feet.

Framingham Reservoirs Nos. 1 and 2, Ashland, Hopkinton and Whitehall Reservoirs.

No water was drawn from Framingham Reservoirs Nos. 1 and 2, Ashland, Hopkinton and Whitehall reservoirs for water supply during the year, but flash-boards were maintained from early in May to late in November on all of the dams except Whitehall Dam, which is not provided with an overflow, and all of the reservoirs have been kept substantially full of water during the year, although the water was drawn down one or two feet at times in anticipation of heavy yields so that the large flows could be regulated and properly controlled.

A discharge of not less than 1,500,000 gallons of water per day was maintained throughout the year from Framingham Reservoir No. 1 into the Sudbury River as required by chapter 177 of the Acts of 1872. The dams, gate-houses, structures and grounds at these reservoirs were cared for in the usual manner.

A bathroom was fitted up in the Bullard house at Framingham Reservoir No. 1 at a cost of \$405.74. Sheds, boat houses, boats and flash-boards were painted at Framingham Reservoirs Nos. 1 and 2 and sprouts and brush were cut along the shores and in the lanes along property lines at these reservoirs.

At Ashland Reservoir the house and barn were painted, the driveway was repaired, a new boat was purchased for use in collecting samples of water for analysis, sprouts and brush were cut along the sides of the outlet channel and for a distance of 4.4 miles and a width of 5 feet in the lanes along property lines.

At Hopkinton Reservoir the northerly half of the roof of the house was shingled and the buildings were painted. Thirteen property line bounds were set on the north shore at the David Allison land. Sprouts and brush were cut along the outlet channel and for a distance of 6.5 miles and width of 5 feet in lanes along property lines.

At Whitehall Reservoir the left side wall of the outlet channel at the dam was rebuilt for a length of 32 feet and an average height of 9 feet. About 60 feet in length of retaining walls 3 feet in height were rebuilt along the sides of the outlet channel below the dam. Sprouts and brush were cut for a distance of 5.7 miles and a width of 5 feet in lanes along property lines. One cottage was built this year by an adjoining property owner and there are now 66 cottages located near the water works lands at this reservoir. There were 5 motor boats, 85 row boats and 26 canoes in use on the reservoir this year, a total of 116 or 10 less than in 1918.

Rutter's Brook in Cedar Swamp, Westborough, was improved for a distance of about one mile from a point near East Main Street to its junction with Jackstraw Brook south of the Boston & Albany Railroad at a cost of \$679. The brush, sprouts, weeds and other growths were cut for a width of 10 feet on both sides of the brook and obstructing roots, hassocks, mud and driftwood were removed from the channel. The railroad culvert was partially cleaned out by the railroad employees.

Fence was built for a distance of 575 feet at the H. A. Gilmore land and for a length of 300 feet at the Ellen O'Brien land.

Farm Pond.

No water has been let into or wasted from Farm Pond during the year. Under rights reserved by legislation the town of Framingham pumped 175,500,000 gallons of water from the filter-gallery on the easterly shore of the pond, and the Boston & Albany Railroad took approximately 62,700,000 gallons and the New York, New Haven & Hartford Railroad took approximately 42,300,000 gallons of water from the pond for use during the year.

Lake Cochituate.

Water was drawn from Lake Cochituate through the Cochituate Aqueduct for water supply from January 28 to April 3. The remainder of the yield of the watershed was wasted at the dam at the outlet and some water was wasted during every month except February.

The iron and wood work and the tin roof at the effluent gate-house and the bridge and ironwork at the outlet dam were painted.

Grass, brush and weeds were mowed for a width of 10 feet on both sides of the open channel on the surface water drain from Cochituate Village and sediment was removed from the channel and catch basins and from the sand catcher at Bannister's Brook.

Brush and sprouts were cut for a distance of 6 miles and a width of 5 feet in the lanes along the property lines, and around the west shore of the lake from the foreman's house to the dam, along both sides of Snake Brook and along the shores at the southerly end of the lake.

On lands near the lake adjoining the water works property there are now 144 cottages, 18 garages and 2 stables, an increase of 11 cottages and 3 garages since 1918. The Natick Club house at the southerly end of the lake was burned during the year.

AQUEDUCTS.

Wachusett Aqueduct.

Water was discharged through the Wachusett Aqueduct from the Wachusett Reservoir on 292 days. The total time that the aqueduct was in use is equivalent to 132 days, 2 hours, 55 minutes. The total quantity of water discharged is 33,702,700,000 gallons, equivalent to an average of 92,336,000 gallons per day for the entire year.

All of the water was used for generating electric energy at the power station before being discharged into the aqueduct.

The Westborough State Hospital pumped 64,398,000 gallons of water from the aqueduct at the terminal chamber during the year. This is equivalent to a consumption of 176,400 gallons per day.

The masonry aqueduct, open channel and appurtenances are in good condition with the exception of the Assabet Bridge which requires waterproofing to stop the leakage which has developed during recent years, and a new granolithic walk on the top.

A wooden shed 19 feet by 23 feet in dimension, for the storage of vehicles, was built near the foreman's tool-house at the lower end of the masonry aqueduct. The materials for this building were secured from trees cut on the water works property and it was built entirely by water works employees, at a cost of \$220.43.

A Wheelock wire fence was erected on property lines for a length of 4.613 miles in Berlin, Northborough and Southborough to replace the original board rail fence erected in 1897. This work cost 19.6 cents per foot exclusive of the cost of the posts which were cut on the water works land. During the past nine years all of the original board rail fence has been replaced with Wheelock wire fence and some additional fence has been constructed.

The water works lands along the 7 miles of masonry aqueduct and the 3 miles of open channel are now enclosed either with Wheelock wire fence or substantial stone walls, except for a distance of about 7,000 feet where the water works lands may have to be enclosed at some future time, but this depends upon the use made of the adjoining lands. Two miles of water works land over the tunnel portion of the aqueduct in Clinton and Berlin have not been enclosed.

Brush, grass and weeds were mowed and disposed of for a distance of 10 miles along the aqueduct at a cost of about \$180 per mile. This is about double the cost of this work for the past few years, due, largely, to mowing large areas this year which had been left during the past two years when labor was scarce and to some extent to increased wages.

Sudbury Aqueduct.

During the year the Sudbury Aqueduct was in continuous service on 365 days with the exception of interruptions of 2 hours on May 23, 2½ hours on May 26, 7 hours on May 29 and 3¾ hours on August 16, when all the flow into the aqueduct was shut off for various purposes in connection with the operation of the works.

The usual current meter measurements to standardize the calculations of flows in the aqueduct have been taken once a month to obtain a coefficient to apply to the daily record of flows as determined by the continuous diagram of elevations in the aqueduct at the Farm Pond gate-house. The variation in this coefficient during the year has been from 86.07 per cent in the summer months to 93.96 per cent at the last of the year, the arithmetical average being 89.30 per cent.

The total quantity discharged into the aqueduct from Framingham Reservoir No. 3 was 24,103,500,000 gallons, and of this 171,300,000 gallons were taken by the Framingham Water Works through its 14-inch sheet iron pipe which is submerged under Farm Pond, leaving the remainder of 23,932,200,000 gallons as the supply delivered to the Metropolitan Water District, or an average of 65,568,000 gallons per day, which is 9,065,000 gallons less than in 1918.

A temporary wooden check valve was placed on the connection with the aqueduct in the gate chamber near the Farm Pond inlet chamber, where the 14-inch sheet iron pipe line of the town of Framingham crosses the pond from the Sudbury Aqueduct to its pumping station, so as to prevent the water in the pond from entering the Sudbury Aqueduct from leaks in the defective pipe when no water is being pumped through it from the Sudbury Aqueduct.

The coverings over the submerged culverts in Farm Pond under the aqueduct were renewed in places and fastened down and the roof of the aqueduct gate-house at the easterly shore of the pond was repaired.

At the office building in Framingham, which is located on the aqueduct land, the roof was repaired, some of the plumbing was renewed and the blue printing tank was relined with zinc, and to protect it from corrosion was given two coats of paint and one coat of white enamel.

The culverts along the aqueduct were kept free from snow and ice during the winter months. The brush, grass and weeds along the aqueduct were mowed and disposed of.

The gaging chamber at Station 59 and the corrugated iron roof of the storehouse at the Rosemary siphon were painted. The iron-work at the waste-weirs and siphon chambers, the fence at Echo Bridge and the manhole covers were painted with black asphalt paint. Some pointing was done at the Rosemary siphon chambers and new steps were built and put in place on the embankments at

this place. The new stop-planks that were made last year were put in the overflows at Course Brook, Bacon's, Fuller's and Clark's waste-weirs.

Weston Aqueduct.

On 303 days water was delivered to the Weston Reservoir from the Sudbury Reservoir through the Weston Aqueduct. The total time of service was equivalent to 183 days, 22 hours and 44 minutes. The total quantity of water delivered was 17,340,700,000 gallons, or an average of 47,509,000 gallons per day, which is 3,003,000 gallons per day less than for the year 1918.

The usual time of running the Sudbury power station is from 6.45 A.M. to 10.45 P.M. except on Sundays and holidays, and, making allowance for preparation of starting and stopping the water wheels, the running of the water in the aqueduct is from 7 A.M. to 10.30 P.M., an interval of $15\frac{1}{2}$ hours. On special occasions the water is run continuously for 24 hours.

Brush, weeds and grass have been mowed and disposed of. The brush and sprouts were cut and cleared up for a distance of about 2,900 feet at the White place and about 3,500 feet south of gaging chamber No. 2, and for a width of 5 feet in the lanes along property lines.

Wire fences have been repaired at several places aggregating nearly a mile in length and over 500 new posts have been set. The plank fence at Potter Street was also repaired; the wood and iron work at the head-house at the Sudbury Dam was painted; and the cleaning screens were painted several times. The house and barn at the White place have been painted, also the manhole covers and the ironwork and woodwork inside and outside of the gaging and siphon chambers. The steps on the embankments have been rebuilt or repaired where necessary, the culverts along the aqueduct have been kept free of ice and snow and the walks and roads have been kept in good order.

Cochituate Aqueduct.

The Cochituate Aqueduct was in use on 4 days in January, all of February and March and 2 days in April, or 65 days in all. The total amount of water drawn through the aqueduct during this time was 713,900,000 gallons.

The interior ironwork at the waste-weirs, the iron manhole covers and the metal roof at the west pipe chamber at the Charles River were painted. The wire fence on property lines at the Harry Felch

land was repaired for a distance of 800 feet. Brush, grass and weeds along the aqueduct were mowed and disposed of, and the culverts were kept clear of snow and ice during the winter.

PROTECTION OF THE WATER SUPPLY.

Sanitary Inspection.

During the winter ice cutting operations were inspected at the various reservoirs and ponds where ice cutting is permitted and during the summer many of the regular water works employees, who were appointed special police, kept a general oversight of the water works lands and waters and four temporary watchmen were employed to prevent bathing and unauthorized boating and fishing in the reservoirs.

The sanitary inspector and one assistant made the usual examinations of conditions on the Wachusett, Sudbury and Cochituate watersheds and a summary of these inspections is given in the accompanying tables.

The number of premises on the Wachusett watershed increased from 1,740 to 1,757 during the year by the construction of 7 new houses in West Boylston, 10 in Holden, 1 in Princeton and 3 summer cottages in Sterling, and the removal of 2 dwellings, an ice house and a chair repository.

The mills at Dawsonville, Eagleville, Jefferson and Quinapoxet were operated at full capacity.

The Mount Pleasant House in Jefferson has been open since May and the Prospect House in Princeton was open during the summer.

Construction work has been continued by the city of Worcester at its Pine Hill Dam and the sanitary conditions about this work have been carefully inspected.

The number of premises on the Sudbury watershed increased from 4,889 to 4,895 during the year by the construction of 8 new buildings and the elimination of 2 old buildings. Three of the new premises are connected with the public sewer and the drainage is carried off the watershed.

The number of premises on the Cochituate watershed increased from 3,216 to 3,250 during the year by the construction of 37 new buildings and the elimination of 3 old buildings. Seventeen of the new premises are connected with the public sewer and the drainage is carried off the watershed.

Summary of Sanitary Inspections on the Wachusett Watershed in 1919.

DISTRICT.	Number of Premises in- spected. ¹	CLASSIFICATION OF CASES INSPECTED.										CONDITION AT END OF YEAR.		WATER SUPPLY.					
		Cesspools dug before 1919.	Cesspools dug during 1919.	Direct Privy Drain- age.	Indirect Privy Drain- age.	Direct Sink Drainage.	INDIRECT SINK DRAINAGE.		BARN DRAINAGE.		Manufacturing Wastes.	Premises Vacant.	No Drainage.	Drainage carried to Filter-beds.	Satisfactory.	Unsatisfactory.	Premises having Pub- lic Supply.	Premises having Pri- vate Supply.	Premises on which no Water is used.
							Satisfactory.	Unsatisfactory.	Satisfactory.	Unsatisfactory.									
French Brook,	70	43	1	-	-	-	21	-	17	-	6	2	-	70	-	7	55	8	
Muddy Brook,	42	19	-	-	-	-	19	-	17	-	2	1	-	42	-	-	39	3	
Gates Brook,	221	157	2	-	-	-	47	3	53	1	11	3	-	218	3	4	203	14	
Malden Brook,	35	15	1	-	-	-	17	-	20	-	2	1	-	35	-	-	32	3	
Chaffin Brook,	222	135	7	-	-	-	63	6	86	-	2	5	-	215	7	94	121	7	
Asnebumskit Brook,	220	163	2	9	2	9	25	2	45	2	2	9	1	205	15	191	18	11	
Muschohauge,	95	43	4	-	-	-	37	-	40	-	1	4	1	94	1	7	82	6	
South Wachusett Brook,	88	40	3	-	-	-	34	-	41	1	11	3	-	87	1	-	74	14	
Front Brook,	34	5	-	-	-	-	23	-	20	-	5	2	-	34	-	-	27	7	
East Wachusett Brook,	216	89	1	-	-	-	86	3	93	-	30	14	1	213	3	-	172	44	
Stillwater River,	142	69	-	-	-	-	46	1	63	3	16	11	1	139	3	-	115	27	
Wachusett,	330 ²	81	2	-	-	-	72	1	59	-	2	14	96	335	1	-	320	16	
French Hill,	36	26	1	-	-	-	6	-	15	-	3	1	-	36	-	-	32	4	
Totals,	1,757	885	23	-	2	9	496 ³	16	569	7	94	70	100	1,723	34	303	1,290	164	

¹ On some premises there are two or more cases.² Including 163 summer dwellings at the Wachusett Ponds.³ Summer dwellings not classified.

Summary of Sanitary Inspections on the Sudbury and Cochituate Watersheds in 1919.

DISTRICT.	Number of Premises in- spected. ¹	CLASSIFICATION OF CASES INSPECTED.										CONDITION AT END OF YEAR.						
		Sewer Connections.	Cesspools dug before 1919.	Cesspools dug during 1919.	Direct Privy Drain- age.	Indirect Privy Drain- age.	Direct Sink Drainage.	INDIRECT SINK DRAINAGE.		BARN DRAINAGE.		Manufacturing Wastes.	Premises Vacant.	No Drainage.	Drainage carried to Filter-beds.	Satisfactory.	Unsatisfactory.	
								Satisfactory.	Unsatisfactory.	Satisfactory.	Unsatisfactory.							
SUDBURY WATERSHED.	328	316	6	1	1	1	1	1	1	1	8	1	1	1	4	1	328	1
	98	—	69	1	1	1	1	23	2	42	1	1	1	—	—	98	2	
	303	—	259	2	1	1	1	22	2	32	1	1	4	6	2	301	1	
	2,035	1,673	253	1	1	1	1	82	1	171	1	1	9	16	1,834	2,034	1	
	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	339	—	260	3	3	3	3	60	1	97	1	1	14	2	—	339	—	
	232	—	214	3	3	3	3	6	—	26	1	1	1	6	—	232	—	
	403	—	234	—	—	—	—	102	6	63	3	1	45	7	—	394	9	
	183	—	106	1	1	1	1	44	3	48	1	1	20	9	—	179	4	
	177	—	58	—	—	—	—	81	1	35	1	1	41	2	—	176	1	
	797	553	173	1	1	2	2	41	3	89	1	1	20 ²	13	—	794	3	
	Totals,	4,895	2,542	1,632	10	—	2	2	461	15	611	5	1	162	65	1,836	4,875	20
	COCHITUATE WATERSHED.	259	—	191	12	—	1	1	13	1	27	1	—	22	—	—	258	1
		1,094	792	245	1	—	—	—	31	—	65	—	1	6	13	1,027	1,094	—
140		2	108	1	—	—	—	16	—	31	—	—	9	1	—	140	—	
1,757		1,368	302	6	—	—	—	51	1	105	1	—	10	16	1	1,755	2	
Totals,		3,250 ³	2,168	846	20	—	1	1	111	2	228	2	1	47	30	1,028	3,247	3

¹ On some premises there are two or more cases.² Eight of these premises connected with the public sewer.³ Including 220 summer dwellings.

Filtration and Chlorination.

On the Wachusett watershed the surface water from 525 acres in the village of Sterling was filtered at the Sterling filter-beds. The sewage from the Worcester County Training School, occupied by about 78 persons, was purified at the filter-beds on Beaman Street in West Boylston. The Gates Terrace filter-beds at Sterling Junction were operated continuously from April 18 to the end of the year, as one cottage is being occupied during the winter. The cost of maintaining all of these filter-beds was \$599.96.

On the Sudbury watershed the surface water from an area of 2 square miles in Marlborough was filtered at the Marlborough Brook filter-beds before it entered the Sudbury Reservoir. At the combination storage reservoir and filter-bed on Farm Road diluted sewage from the Marlborough sewer was filtered on one day in February, 16 days in March and 22 days in April, and the ground water from the sewer underdrain was filtered during every month. The periodical cleaning of the settling basins at Marlborough Brook, which was due this year, was deferred because of the scarcity and high price of labor; otherwise the filters and appurtenances were given the usual care and attention, the surface of the beds being cleaned during the summer and again in the fall.

The necessary repairs and cleaning at the Southborough swimming pool having been attended to by the town the pool was used freely during the summer. The water was changed twice a week while the pool was in use and the drainage was purified at the filter-bed located below the pool, which has been cleaned several times and kept in good order.

The surface water from Cherry Street Brook at Fayville was treated with calcium hypochlorite whenever there was any probability of pollution from the adjacent premises.

The cost of filtration and chlorination on the Sudbury watershed was \$2,162.04.

On the Cochituate watershed all of the surface water from the thickly settled area of about one square mile tributary to Pegan Brook in Natick was pumped and filtered at the Pegan filtration works, but the area tributary to the intercepting ditch furnished more water than could be cared for on 1 day in January, 1 day in February, 7 days in March and 1 day in November, the aggregate

overflow amounting to 7,700,000 gallons, which was treated with calcium hypochlorite. The pumping station was operated on 272 days during the year and 408,410,000 gallons of surface water, equivalent to an average of 1,119,000 gallons per day for the entire year were pumped to the filter beds. The cost of operating and maintaining the pumping station and filter-beds was \$6,429.49, or at the rate of \$15.74 per million gallons pumped. Early in the year a 20-inch by 12-inch Venturi meter was installed in the force main between the pumping station and the filters for measuring the quantity of water pumped. The grounds, filter-beds and pumping plant were kept in good condition and the intercepting reservoir was cleaned and about 760 cubic yards of sediment removed at a cost of \$229.92.

Improvement of Swamps and Brooks.

The ditches maintained in the swamps on the watersheds for improving the quality of the water were cleaned and weeds and brush mowed for a width of 10 to 20 feet on both sides where necessary at a cost of \$2,063.78 for the 27.73 miles connected with the Wachusett works and a cost of \$1,019.94 for the 8.94 miles connected with the Sudbury works.

A Wheelock wire fence 3,220 feet in length, erected in 1912 to enclose drainage ditches constructed through a portion of Little Crane Swamp in Northborough, was reconstructed with watering places and bridges in accordance with the terms under which the enclosed area became the property of the Commonwealth in 1918. This work cost 15 cents per linear foot.

The work of improving Gates Brook in the Wachusett watershed was not resumed this year on account of scarcity and high price of labor.

The flow of the brook through land acquired from the town of Framingham on Pleasant Street, which ran directly into the reservoir, was intercepted by a trench and an outlet was made connecting the trench with an old gravel pit in which the flow was stored and allowed to seep off or filter without overflowing into the reservoir and the old brook channel was filled in for about 100 feet.

Purchase of Land.

For the protection of the water supply on the Wachusett watershed 31.29 acres of land, located along the Quinapoxet River and on Main Street, West Boylston, and along the Stillwater River and Waushacum Brook, Sterling, were acquired during the year; also about 50 acres of land in Boylston, which drained either directly into the Wachusett Reservoir or Malagasco Brook, was purchased, but the surveys and takings have not as yet been completed. Wooden frame buildings on two of these parcels and one on the former Stone property on Waushacum Street, Sterling, were sold and moved to locations outside the watershed. The wooden boat-club house on Middle Waushacum Pond in Sterling, owned by the Gates Terrace Boat Club, was removed late in the year in accordance with the terms of the lease which expired October 1, 1919.

CLINTON SEWAGE DISPOSAL WORKS.

Pumping Station.

In connection with the operation of the Clinton sewage disposal works, under the provisions of chapter 557 of the Acts of the year 1898, the pumping station was operated daily with the exception of 5 days between May 22 and 28 when operation was impossible on account of high water in the Nashua River which flooded the station.

The quantity of sewage pumped to the filter-beds averaged 1,168,000 gallons per day, which is 103,000 gallons per day more than in 1918. All of the sewage was pumped with the electrically driven 12-inch DeLaval centrifugal pump installed in 1912, except 295,000 gallons on February 17 and 18 when the electric service was interrupted by the accident at the Wachusett power station and some pumping was done with the old Blake compound duplex steam pump, which is held in reserve, but on account of the failure of several of the boiler tubes it was necessary to shut down the steam plant. On February 17, 18 and 19, on account of the accident, and again between May 22 and 28, on account of high water, sewage overflowed into the South Branch of the Nashua River for 182 hours and 25 minutes. The pumping statistics are as follows:—

Total pumpage (gallons),	420,402,000
Average pumpage (gallons per day),	1,168,000
Electric energy used (kilowatt hours),	139,123
Pumpage per kilowatt hour (gallons),	3,020
Average lift (feet),	49.8
Efficiency of pumping unit and transmission line (per cent),	52.5
Coal used for burning sludge and heating (pounds),	65,790

Cost of pumping:—

Labor,	\$1,375 54
Electric energy at \$5.30 per thousand kilowatt hours,	737 35
Coal for burning sludge and heating,	230 51
Repairs and supplies,	577 11

Total for station, \$2,920 51

Cost per million gallons,	\$6.95
Cost per million foot gallons,1395

The slate roof and copper flashing of the pumping station and the cast-iron cap, brickwork and lightning rod of the chimney were repaired at a cost of \$90.60.

Filters.

With the exception of from May 16 to 22 and from May 28 to June 5, inclusive, the filter-beds and settling basins were operated by first passing the sewage through one of five settling basins the effluent from which was applied to the 25 one-acre filter-beds in regular doses of 59,000 gallons in 30 minutes at intervals of about $1\frac{1}{3}$ days. The rate of filtration averaged about 44,000 gallons per acre per day. The cost of filtration during 1919 was as follows:—

Labor,	\$7,708 84
Supplies and expenses,	1,371 09

Total, \$9,079 93

Cost per million gallons,	\$21 60
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This high cost of filtration is due in part to higher wages and increased cost of supplies, but largely to the condition of the filters which have been overworked for some time. The character of the effluent for the past five years is shown by the following table:—

[Parts per 100,000.]

	1915.	1916.	1917.	1918.	1919.
Albuminoid ammonia, sewage,	1.4350	1.0255	.8652	.8792	.6265
Albuminoid ammonia, effluent,09347	.0983	.1383	.1439	.0908
Reduction, per cent,	93.5	90	84	83.6	86
Free ammonia, sewage,	3.7867	2.7850	3.4707	3.2300	3.0925
Free ammonia, effluent,5924	1.0316	1.7658	1.5094	1.5571
Reduction, per cent,	84	63	49	53	50
Nitrogen as nitrates, effluent,7152	.3693	.20165	.2866	.1818
Iron, effluent,30815	1.052	2.036	1.903	2.5644
Average quantity of sewage filtered, gallons per day.	941,000	1,225,000	1,050,000	1,037,000	1,168,000

Corn and tobacco were grown on two of the gravel beds and one of the loam beds as an experiment to see if the capacity of the filters could be increased in this manner. The crops did finely on the loam bed and very poorly on the gravel beds, but instead of being increased the capacity of the filters was somewhat reduced as these beds could not be used in regular turn without flooding and killing the plants.

The work of washing the filtering material for a depth of 6 to 10 inches from the surface of the gravel beds, which was begun in 1918, was resumed in June and continued through October. The plant was the same as used last year with the addition of another portable pumping unit and a 3-inch discharge pipe line for removing the dirty water and sludge, and an elevator for handling the washed material. After using the elevator for a few weeks the gasoline engine which operated it was accidentally broken, and while repairs were being made it was found that a man with a one-horse drag-scoop could keep the washing machine free of washed material and regrade the bed at less cost than with the elevator, which, after repairs, was sent to the Chestnut Hill pumping stations to be used in handling coal. A force of 8 men and 2 horses was employed, and about 2,400 cubic yards of material from two of the gravel beds, each approximately one acre in area, were washed at a cost of \$3,700. The cost per cubic yard of material washed was \$1.50 this year, 25 cents less than last year although wages had increased 16 per cent.

The top 6 to 10 inches of filtering material on beds Nos. 2, 5 and 14 has now been washed by this method and sewage is being ap-

plied to these beds in doses of about 58,000 gallons in 30 minutes at intervals of about 2 days, which is equivalent to a rate of filtration of about 29,000 gallons per acre per day. Under these conditions the beds are operating in a satisfactory manner and the effluent from them again contains dissolved oxygen.

FORESTRY.

Wachusett Lands.

Parcels of water works land bordering on the Wachusett Reservoir in Boylston and Sterling, which had recently been burned over or were grown to chestnut trees affected by the bark disease, having a total area of 22 acres, were cleared for planting with pine seedlings. This work cost about \$53 per acre, but as cross ties, fence posts and cordwood having a value of \$996 were obtained the net cost is about \$8 per acre.

Thirty-four acres of water works land in Sterling west of the North Dike and 4 acres on Beaman Street in West Boylston, which had been planted and since burned and cleared for planting again, were replanted with 35,700 Scotch pine seedlings 4 years old and 1,700 white spruce seedlings 7 years old from the Oakdale nursery. The cost of preparing the trees in the nursery and field planting them was \$22.28 per thousand or \$24.50 per acre.

Plantings on parcels of water works land located along the margins of the Wachusett Reservoir in Clinton, Sterling and West Boylston, aggregating 38 acres, were filled in where the original trees had failed with 11,200 white pine seedlings 5 years old from the Oakdale nursery at a cost of \$18.80 per thousand.

At the end of the year the Oakdale nursery contained the following seedlings: —

White pine 2 years old in seed beds,	15,500
White pine 3 years old in transplant beds,	42,900
White pine 4 years old in transplant beds,	6,900
White pine 5 years old in transplant beds,	44,000
White pine 6 years old in transplant beds,	700
Red pine 3 years old in transplant beds,	400
Red pine 7 years old in transplant beds,	100
White spruce 8 years old in transplant beds,	8,000
Maple 3 years old transplanted from field,	750
Total,	119,250

All of the Norway pine, tamarack and sequoia seedlings on hand last year were winter-killed.

The sprouts and undergrowth which were interfering with the pines planted during the past few years on about 98 acres of land along the open channel portion of the Wachusett Aqueduct and on the margins of the reservoir were cut and disposed of at a cost of \$10.57 per acre, but as cordwood valued at \$150 was obtained from this work the net cost is \$9.04 per acre.

Work on improvement thinning of a portion of Big Crane Swamp in Westborough, thickly grown to cedars, which was in progress late in 1918 was continued into the early spring of 1919 and was resumed again just before the close of the year. About 3 acres were improved at a cost of \$1,949.40, and there were secured from the operation 151,000 shingles, 1,420 fence posts and 45 cords of wood having an estimated value of about \$1,600. The shingles and posts were used in connection with water works operations and the cordwood was sold.

The trees and shrubbery at the Wachusett Dam and the trees on water works land adjacent to the main highways at the Wachusett Reservoir, Waushacum Ponds and the Sterling and Clinton sewerage filter beds, and on several large areas of forest land on the margin of the Wachusett Reservoir which were badly infested with gypsy moths, were sprayed with 7,500 pounds of arsenate of lead during May and June at a cost of \$1,564.70. An auto truck with power sprayer was used for all of this work.

In the fall of the year about 13,000 egg clusters of the gypsy moth on trees and shrubbery at the Wachusett Dam were painted with creosote at a cost of \$136.07.

During June and July many of the white pine plantings on the marginal lands around the reservoir and along the open channel portion of the Wachusett Aqueduct were inspected for the pine tree weevil on two occasions. A total of about 43,000 infected shoots were cut and burned at a cost of \$775.23. The number of trees attacked by the weevil increases each year, and as it is necessary to confine this work to trees of medium height and under the value of the pine stands is being considerably reduced.

The total cost of protecting the trees and plantings from insects and disease during the year was \$2,476.

The usual fire patrol service was maintained during the spring

and fall. Four fires, involving considerable damage to the white pine plantings and some damage to the hard wood growth, occurred during March and April, and three of them were due to gross carelessness on the part of owners of adjacent lands. On March 26 a grass fire spread from the property of an adjoining owner in West Boylston, near the Sterling town line, and burned over about 90 acres of water works land, 71 acres of which were grown to gray birch, sprout and brush, 15 acres to white pine from 12 to 15 feet high, planted in 1904, and 4 acres to white pine from 3 to 5 feet high, planted in 1913. About 6,000 of the large trees and 4,500 of the smaller ones were destroyed. On April 23, sparks from a locomotive on the New York, New Haven & Hartford Railroad started a fire among the young pines on a lot in Southborough near the upper dam of the open channel portion of the Wachusett Aqueduct and burned over about 2 acres of land, destroying 1,500 white pine trees from 2 to 3 feet in height. The Railroad Company reimbursed the Commonwealth for the loss, which amounted to \$29.85. On April 23 a brush fire spread to one of the finest white pine stands on the water works lands, located back of the South Dike in Clinton. The abutting owner was engaged in clearing and burning brush on a piece of meadow land adjoining the water works property and left his work at noon with the fires apparently all out. A very high wind was blowing and some live ashes were blown into the dry grass and brush which caught fire and about 15 acres of water works land planted to white pine in 1908 were burned over, destroying about 18,000 trees from 10 to 15 feet high. The abutting owner was prosecuted by the deputy State forest fire warden, was found guilty of burning brush in the open without a permit and was fined \$75.

The brush, grass and weeds were mowed and burned on 23 miles of marginal fire guard which is 40 feet wide and on 40 miles of forest roads from 15 to 45 feet wide. This mowing, which had been somewhat neglected for several years, cost \$54.70 per mile.

A marginal strip 100 feet in width along the main highways bordering the water works land around the Wachusett Reservoir was cleared of all brush and undergrowth and the trees were trimmed as a means of preventing roadside grass fires from spreading to the improved and planted water works lands. At the close of the year 99 acres along $6\frac{1}{4}$ miles of highway had been improved in this manner at a cost of \$38.50 per acre and the work was still in progress.

The marginal grass strip between the traveled roadways and the water works lands was burned over in the early spring along about 14 miles of the highways bordering the reservoir at a cost of \$318.21.

At the close of the year the Wachusett lands may be classified as follows: —

Forest lands acquired and not since improved (acres),	1,410
Forest lands acquired and since improved (acres),	330
Land which has been planted with trees and not cleared (acres),	238
Land which has been planted with trees and since cleared (acres),	1,285
Land to be planted with trees (acres),	622
Open land which will probably not be planted (acres),	820
Marginal strip along shore of the reservoir (acres),	212
Total,	4,917

The total expenditures for forestry on the Wachusett lands during the year amount to \$12,620.71.

Sudbury and Cochituate Lands.

At the Sudbury Reservoir nursery 125,000 white pine seedlings 2 years old and 10,000 4 years old were on hand at the beginning of the year, and in May 100,000 white pine seedlings 2 years old were received from the State nursery at Amherst.

Of the 135,000 seedlings on hand at the beginning of the year 54,300 were set out on the land back of the Bigelow place on Farm Road, 42,000 on Pine Hill, 11,400 on the A. J. Newton land, and 10,000 4 years old and 4,350 2 years old were used to replace pines lost by fires and for filling in at other places at the Sudbury Reservoir. There were also 3,750 pines used to replace dead trees on the southerly shore of Framingham Reservoir No. 3 and 2,400 used at Lake Cochituate.

Of the 2,400 pines received from the Sudbury Reservoir and 13,700 4-year-old pine seedlings from the West Pond Street nursery at Lake Cochituate, 1,000 were planted in the sand borrow pit east of gaging chamber No. 2 of the Weston Aqueduct, 5,500 at the cut easterly of Wellesley Avenue and 1,200 west of the storehouse at the Rosemary siphon chamber on the Sudbury Aqueduct, 3,000 near Morse's Pond on the Cochituate Aqueduct, 3,000 at the pasture north of Snake Brook at Lake Cochituate and 2,000 on the shores of the lake near the outlet dam.

About 85 acres of woodland at Pine Hill and back of the Bigelow place on Farm Road at the Sudbury Reservoir were cleared in

preparation for setting out pine seedlings. Of this area the water works employees cleared 35 acres from which 2,500 chestnut fence posts were cut and the remaining 50 acres were cleared by parties to whom the wood was sold.

Part of the trees at the Sudbury Reservoir, Framingham Reservoirs Nos. 1, 2 and 3, Lake Cochituate and the Weston Aqueduct were sprayed with arsenate of lead in May and June. The power sprayer in use on the Sudbury works was disabled at the last of the season, and the one used at the distribution reservoirs was transferred to finish the work. The sprayers were in use $30\frac{1}{4}$ days with an average force of 8 men and 9,000 pounds of arsenate of lead were used. The total cost of the work was \$2,080.69.

On the Sudbury and Cochituate lands 218,800 gypsy moth egg masses were painted with creosote at a cost of \$668.50.

Brown-tail moth caterpillars were destroyed within 50 feet of the highways at Lake Cochituate and at the Framingham and Sudbury reservoirs as far as the time and means at hand would permit.

At the Sudbury Reservoir 19,000 leaders affected by the pine-tree weevil were cut off at a cost of \$386.87, and along the Weston Aqueduct 1,100 were cut.

Fires of unknown origin, which occurred at the Sudbury Reservoir and along the Cochituate Aqueduct in February, March and July, destroyed about 1,100 pines 3 feet to 6 feet high and about 1,300 smaller trees.

The total amount expended for forestry on the Sudbury and Cochituate lands during the year was \$9,165.35.

Distribution Reservoir Lands.

Gypsy and brown-tail moths and elm-leaf beetles were destroyed on distribution reservoir lands as in former years by spraying the foliage with arsenate of lead during the crawling season and by painting the gypsy moth egg clusters with creosote and burning the brown-tail moth webs during the winter. A 2-horse-power sprayer was used for spraying and 3,560 pounds of arsenate of lead in paste form were used.

Oyster scale, found on shrubs at Chestnut Hill Reservoir, was destroyed by using scalecide and Arlington oil.

The leaders on pine trees at the Weston Reservoir, which were infested with the pine-tree weevil, were cut off and burned.

The total expenditure for this work was \$2,277.60.

HYDRO-ELECTRIC SERVICE.

The total quantity of electric energy delivered during the year from the two hydro-electric stations which are operated in connection with the Metropolitan Water Works was 12,851,461 kilowatt hours.

The total value of this energy at the contract prices is \$73,227.70. The total expenses chargeable to both stations are \$41,434.69, leaving a profit for the operation of the stations of \$31,793.01, equivalent to \$2.474 per thousand kilowatt hours.

Although the abundant yield during the year permitted the generation of 642,573 kilowatt hours of electric energy from 2,549,600,000 gallons of water which were not required for consumption but were wasted through the turbines to conserve the power, the total energy generated in 1919 is about 9 per cent less than in 1918.

This is accounted for by the unusually large consumption in 1918, due to war activities and the extremely cold weather, as compared with reduced consumption in 1919, due to mild weather and the cessation of war work.

Wachusett Service.

The Wachusett power station was operated on 279 days during the year, and all energy not used in connection with the operation of the Metropolitan Water Works was sold to the New England Power Company and the Edison Electric Illuminating Company of Boston under the contract dated January 13, 1917.

This contract provides for the construction by the Commonwealth of a 66,000-volt transmission line between the Wachusett and Sudbury power stations and for the purchase by the companies of all of the energy available from the water drawn from the Wachusett Reservoir for water supply up to a maximum of 7,000,000 kilowatt hours per year. The Wachusett-Sudbury transmission line was completed in July, 1918, and was turned over to the companies at midnight December 31, 1918. According to the provisions of the contract they are to maintain and operate the line for a period of

ten years from that date. On account of delay in the completion of the Edison Electric Illuminating Company's connecting line the Wachusett-Sudbury transmission line had not been put into regular service at the end of the year, but on August 9 the company had completed its outdoor sub-station, which is located on water works land on the hillside at the northerly end of the Sudbury Dam, and established a connection of small capacity from the transmission line through the Sudbury power station to its Hopkinton line. At the close of the year the Edison Electric Illuminating Company's transmission line was connected through to its L Street power station in South Boston and some of the preliminary tests necessary for putting it into service had been completed.

In the spring while water was being wasted from the reservoir the head gates installed in 1918 at the entrance to the Wachusett Aqueduct were tested and their operation was entirely satisfactory. It was found that by using the head gates as planned water could be wasted at the rate of about 300,000,000 gallons per day from the reservoir through the turbines into the Nashua River and utilized for the generation of electric energy. In making the tests 372,300,000 gallons of water were discharged through the turbines into the river.

On account of the abundant yield in November and the high stage of the water in the reservoir at the beginning of December water was wasted through the turbines into the river on every day that the power station was operated from December 3 to the end of the year, the total waste at this time amounting to 1,215,900,000 gallons.

The total electric energy generated with all of the water wasted through the turbines into the river is 331,221 kilowatt hours, which was sold to the electric companies at the contract price for the sum of \$1,755.47. The total amount of energy sold to the companies during the year exceeds the contract maximum by 474,485 kilowatt hours.

About 7.30 A.M. February 17 a serious accident occurred at the Wachusett power station. The operator, in attempting to correct a fault in the operation of the oil pump on turbine No. 2, disconnected the governor so that the wicket gates, which were nearly wide open, closed suddenly and the resulting water ram broke out a large section of the top portion of the scroll case.

The water flowed out of this opening, which had an area of $17\frac{1}{2}$ square feet, under a head of 70 feet, and broke in the door leading from the superintendent's office to a balcony overlooking the generating room and about 12 feet above the floor, and swept through the office which, fortunately, was unoccupied at the time, completely wrecking everything within eight feet of the floor and destroying all of the office records.

In the generating room windows and doors and wooden partitions were broken down by the force of the water, some of which spurted up to the top of the room, about 35 feet above the floor. The water flooded the floor to a depth of 4 feet and flowed out of the doors and windows over the lawn, driveway and walks into the river and through a floor grating into the Wachusett Aqueduct.

At the time of the accident exciter No. 2 and generating units Nos. 1, 2 and 4 were in operation. The operator disconnected the generators from the line before leaving the building but was unable to close the hydraulic valves on the pen stocks. It was therefore necessary to shut off the water by closing the sluice gates in the dam, and as electric power was not available this had to be done by hand, but was completed 35 minutes after the accident occurred.

The rotors of generators Nos. 1 and 4 continued to revolve for a time partly submerged in the water, and the insulation of the field and armature coils was cut and scraped in places. There was also injury of this nature on generator No. 2, but none on generator No. 3 which was not in operation.

All of the electrical apparatus was thoroughly soaked in water, and the governor on turbine No. 2 was damaged somewhat by fragments of metal from the broken scroll case.

Immediately after the water in the generating room had receded repairs were begun by the station employees, and two days later by men from the Standardizing and Testing Department of the Edison Electric Illuminating Company of Boston, and from time to time by repair men especially trained in the required line of work at hand. The repairs comprised a complete overhauling, drying out, replacing of broken parts and appliances and testing of the entire electrical generating apparatus and water wheels and governors.

On the third night after the break a temporary connection had been made with the New England Power Company's line, and alternating current was available for drying and testing the electrical

apparatus and for operating the Clinton sewerage pumping station. Unit No. 3, which was not injured except by moisture, was first dried out and tested and was put into regular service February 25, eight days after the break occurred. Unit No. 1 was next repaired and dried out and was put into service March 4, while unit No. 4 was put into service March 7. With these three units available the normal operation of the station was resumed, but the repairs to turbine No. 2 were not completed until August 2 as it was necessary to obtain and install a new top section of the scroll case on this unit.

Soon after resuming operations it became evident from several failures that the rubber insulation on the main cables leading from the generators to the switch board was in poor condition and they were replaced with paper insulated cables and new terminals.

In addition to the repairs to the generating plant the building and grounds have been put in good condition, and the office has been repaired and equipped with new furniture. The expenditures for all of this work amount to \$11,260.52.

Additional electrical apparatus required when operating with water wasted into the Nashua River and protective devices to insure the safety of the operators and equipment have been installed by the regular station employees during the year at a cost of \$1,837.70.

During an extremely heavy and extended electrical storm on Sunday, August 24, a transformer in the sub-station of the New England Power Company at the Lancaster Mills, Clinton, failed and simultaneously one of the strain insulators in the lightning arrester station at the Wachusett Dam broke down causing a short circuit which set fire to a window frame, but no serious damage resulted and the broken insulator was promptly repaired.

The Wachusett hydro-electric statistics for the year 1919 are as follows: —

Total energy developed (kilowatt hours),	7,672,505
Energy used at power station (kilowatt hours),	58,897
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Available energy (kilowatt hours),	7,613,608
Water used (gallons),	35,290,900,000
Average head (feet),	95.9
Energy developed per million foot gallons (kilowatt hours), . .	2.27
Efficiency of station (per cent),	72.14

Credits: —

Energy sold New England Power Company and Edison Electric Illuminating Company, 7,474,485 kilowatt hours at \$0.0053, . . .	\$39,614 77	
Energy furnished Clinton sewerage pumping station, 139,123 kilowatt hours at \$0.0053, . . .	737 35	
Rental, transmission line location, . . .	139 00	
		<hr/> \$40,491 12

Charges: —

Superintendence,	\$1,089 77	
Labor, operating station,	7,303 85	
Repairs and supplies: —		
Power station,	\$1,238 93	
Transmission line,	98 05	
		<hr/> 1,336 98

Alterations and additions: —

Labor,	\$114 75	
Apparatus and supplies,	1,722 95	
		<hr/> 1,837 70

\$11,568 30

Taxes,	2,825 00	
Administration, general supervision, interest and sinking fund,	9,769 06	
		<hr/> 24,162 36

Profit,	\$16,328 76
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Cost of available energy per thousand kilowatt hours,	\$3.174
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Sudbury Service.

The Sudbury power station was operated on 303 days during the year and on 251 of these days the station was operated two shifts of 8 hours each, from 6.45 A.M. to 10.45 P.M.; on the remaining 52 days it was operated three shifts of 8 hours each in order to maintain the water supply and also to utilize waste water available in December. It was not necessary to operate the station on any Sunday or holiday during the year.

On account of the abundant supply of water from the Wachusett watershed the Sudbury station was operated at maximum capacity rather than at maximum efficiency a large part of the time and the average efficiency is less than for last year. No water was by-passed around the turbines and all the water drawn from Sudbury Reservoir

was used to generate electricity excepting about 300,000,000 gallons wasted over the overflow of the dam in May and June.

In December 499,400,000 gallons of water not needed at Weston Reservoir were discharged through turbines Nos. 1 and 2 into the Weston Aqueduct head house and turned back through the No. 3 60-inch pipe into the open channel which supplies Framingham Reservoir No. 3. The total quantity of water not required for consumption wasted through Nos. 1 and 2 turbines in this manner or through No. 3 turbine so as to conserve the power was 961,400,000 gallons, from which 115,755 kilowatt hours of electric energy was obtained and sold for the sum of \$723.47.

The wheel pits and the portion of the machinery located below the power station floor were inspected several times during the year. The steady bearings were adjusted and leaks in the masonry walls of No. 2 wheel pit were pointed with oakum and lead wool.

During the year service was interrupted by troubles on the Edison lines on several occasions, but the operating time lost was inconsiderable excepting on June 4, when operation was suspended for 9³/₄ hours on account of a burned out insulator on the Edison line at Worcester Street.

The poles on the 4,000 feet of the Hopkinton 13,800-volt transmission line owned and maintained by the Commonwealth were marked with metal danger tags and numbers from 415 to 456 were stencilled on painted panels on the poles. Brush and weeds on this line were cut and burned twice during the year.

The Sudbury hydro-electric statistics for the year 1919 are as follows:—

Total energy developed (kilowatt hours),	5,249,400
Energy used at power station (kilowatt hours),	11,547
	<hr/>
Available energy (kilowatt hours),	5,237,853

Framingham Reservoir No. 3 service:—

Water used (gallons),	22,756,000,000
Average head (feet),	65.79

Weston Aqueduct service:—

Water used (gallons),	17,840,100,000
Average head (feet),	39.15
Energy developed per million foot gallons (kilowatt hours),	2.391
Efficiency of station (per cent),	76.1

Credits:—

Energy sold Edison Electric Illuminating Company of Boston, 5,237,853 kilowatt hours at \$0.00625,	\$32,736 58
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Charges:—

Superintendence,	\$1,346 78	
Labor, operating station,	8,243 38	
Repairs and supplies,	549 31	
Alterations and additions:—		
Labor,	\$259 69	
Apparatus and supplies,	365 63	
	<hr/>	625 32
		<hr/>
		\$10,764 79
Taxes,	1,094 30	
Administration, general supervision, interest and sinking fund,	5,413 24	
	<hr/>	\$17,272 33
Profit,		<hr/>
		\$15,464 25
Cost of available energy per thousand kilowatt hours,		\$3.298

DISTRIBUTION PUMPING SERVICE.

The total quantity of water pumped at the five distribution pumping stations during the year was 29,393,480,000 gallons, and 3,800,-890,000 gallons, or 11.45 per cent, less than the quantity pumped in 1918. Of the total quantity of water supplied to the Metropolitan Water District in 1919, 66.2 per cent was pumped for the northern low, high and extra high services and the southern low service, and 0.58 per cent was repumped for the southern extra high service.

The total cost of operating all the pumping stations for the year 1919 is \$198,723.02. Compared with the previous year there is an increase of about \$15,000 for operating labor, due to increased wages to meet the high cost of living; an increase of about \$13,000 for repairs which had been deferred during the war on account of difficulty in obtaining the necessary labor and materials, and an increase of about \$2,700 in the cost of supplies, making a total increase for these items of about \$30,700, but as there was a saving of about \$18,700 in the cost of fuel the net increase is about \$12,000.

Fuel.

At the beginning of the year there were 1,534 gross tons of bituminous coal and 1,486 gross tons of anthracite screenings on hand at the pumping stations.

Between January 1 and May 1 about 2,000 gross tons of bituminous coal were purchased of E. Russell Norton, under an agreement made in 1918, on the basis of the United States Fuel Administration price of \$3.31 per gross ton at the mines plus 17 cents per gross ton for dealer's commission.

About April 1 two cars of bituminous coal were purchased from the Shaftsbury Coal & Coke Company for \$2.80 per gross ton at the mines, and on April 9 an order was placed with the company for nine additional cars at the same price, but subject to the bonus and penalty specification of our 1917 contract with the company. Altogether there were 556 gross tons of this coal, which proved to be of very poor quality, the average of ten analyses being 13,661 British thermal units per pound of dry coal and 13.38 per cent ash, but after making the specified deductions for quality the price paid for the coal was only \$2.30 per gross ton at the mines.

Early in May a contract was made with the George E. Warren Company of Boston for furnishing 8,000 gross tons of bituminous coal for the pumping stations on the basis of \$3.09 per gross ton at the mines for coal of specified standard quality. This price was subject to an increase at the rate of 4 cents per ton for 100 British thermal units per pound of dry coal over 14,600 and to a decrease at the rate of 6 cents per ton for 100 British thermal units per pound of dry coal under 14,600. The price was also subject to a decrease at the rate of 4 cents per ton for each per cent of ash over 8 per cent in the dry coal. Under this contract 4,570 gross tons of bituminous coal were received during the year and 30 cars, or approximately 1,500 gross tons, shipped for the pumping stations during the miners' strike, were diverted by the United States Railroad Administration. At the close of the year there are 1,103 gross tons of bituminous coal on hand at the pumping stations.

Anthracite coal yard screenings have been purchased from various dealers during the year from time to time when favorable prices were offered. The total amount purchased was 2,900 gross tons and the price paid per gross ton varied from \$2.53 to \$4.98, an average of \$3.83 for screenings delivered on trucks at the stations. At the

close of the year there were 1,500 gross tons of anthracite screenings on hand at the stations.

By spreading bituminous coal and anthracite screenings in alternate layers in the bins very satisfactory results have been obtained from mixtures containing from 30 to 50 per cent of the screenings. A noticeable saving has been made by using the mixed fuel and there has been a marked decrease in the amount of smoke issuing from the chimneys.

The amount and cost of the coal received at the pumping stations during 1919 are as follows:—

DEALER AND KIND OF COAL.	STATIONS (AMOUNT IN GROSS TONS).						
	Chestnut Hill Storage Pile. ¹	Chestnut Hill No. 1. ²	Chestnut Hill No. 2. ³	Spot Pond. ⁴	Arlington. ³	Hyde Park. ³	Cost per Gross Ton in Bins. ⁵
<i>Bituminous.</i>							
George E. Warren Co.,	-	1,094.64	-	-	-	-	\$6 89
E. Russell Norton,	-	805.94	-	-	-	-	7 35
George E. Warren Co.,	-	-	2,812.59	-	-	-	6 58
E. Russell Norton,	-	-	902.68	-	-	-	7 05
Shaftsbury Coal & Coke Co.,	-	-	261.83	-	-	-	5 79
George E. Warren Co.,	-	-	-	431.06	-	-	7 88
E. Russell Norton,	-	-	-	189.79	-	-	8 40
Shaftsbury Coal & Coke Co.,	-	-	-	194.58	-	-	6 99
George E. Warren Co.,	-	-	-	-	141.88	-	7 09
E. Russell Norton,	-	-	-	-	98.70	-	7 51
Shaftsbury Coal & Coke Co.,	-	-	-	-	100.80	-	6 05
George E. Warren Co.,	-	-	-	-	-	91.78	6 91
F. W. Darling Co.,	-	-	-	-	-	2.39 ⁶	10 08
Totals,	-	1,900.58	3,977.10	815.43	341.38	94.17	-
Average cost:—							
In bins,	-	\$7 09	\$6 63	\$7 79	\$6 90	\$6 99	-
On cars and trucks,	-	6 54	6 48	6 78	6 75	6 73	-
<i>Anthracite Screenings.</i>							
Batchelder Bros.,	822.26 ⁶	-	-	-	-	-	-
Brighton Coal Co.,	89.31 ⁶	-	-	-	-	-	-
Metropolitan Coal Co.,	-	136.51 ⁶	-	-	-	-	\$6 09
John A. Whittemore's Sons,	-	119.97 ⁶	-	-	-	-	5 71
Metropolitan Coal Co.,	-	-	651.36	-	-	-	4 95
John A. Whittemore's Sons,	-	-	13.96 ⁶	-	-	-	5 55
Locke Coal Co.,	-	-	-	344.34 ⁶	-	-	5 88
Wilbur W. Fiske & Co.,	-	-	-	139.65 ⁶	-	-	5 59
Batchelder Bros.,	-	-	-	129.10 ⁶	-	-	4 95
Locke Coal Co.,	-	-	-	-	100.00 ⁶	-	5 65
Metropolitan Coal Co.,	-	-	-	-	128.08 ⁶	-	3 70
Batchelder Bros.,	-	-	-	-	44.64 ⁶	-	3 27
Batchelder Bros.,	-	-	-	-	-	180.44 ⁶	2 90
Totals,	911.57	256.48	665.32	613.09	272.72	180.44	-
Average cost:—							
In bins,	-	\$5 91	\$4 96	\$5 62	\$4 35	\$2 90	-
On cars and trucks,	\$2 53	4 33	4 54	4 98	4 05	-	-

¹ Unloaded in storage pile, later to be transported 300 feet and put into bins.

² Hoisted from cars and wheeled to bins.

³ Dumped from cars into bins.

⁴ Unloaded at freight yard, teamed 1½ miles, and dumped into bins.

⁵ Includes cost of unloading coal from cars and all expenses incidental to the mixing and storage of the coal.

⁶ Delivered at station by truck.

All coal received during the year was sampled and analyzed and the results are as follows:—

KIND OF COAL.	Number of Samples tested.	British Thermal Units.	Percent- age of Volatile Matter.	Percent- age of Ash.	Percent- age of Moisture.	Percent- age of Fixed Carbon.
Davenport,	16	14,634	19.80	7.61	3.07	72.59
Shaftsbury,	10	13,661	20.72	13.38	2.75	65.90
Nanty-Glo,	61	14,745	19.86	6.68	3.55	73.46
Loyal Hanna Mine No. 6, .	5	14,562	17.05	7.56	4.06	75.39
"E" Seam,	1	14,084	23.21	11.22	2.45	65.57
Anthracite screenings, .	47	12,661	5.04	14.58	5.73	80.38

Chestnut Hill Pumping Stations.

At Chestnut Hill Station No. 1 new grates were installed in boilers Nos. 1, 2 and 11, considerable boiler feed-water piping was renewed, and a large amount of general repair work was done on engines Nos. 1, 2 and 4. New lightning rod tips were installed on the chimney and the masonry was repointed where necessary.

At Chestnut Hill station No. 2 a large amount of general repair work was done in the boiler and engine rooms. The double-coil heater, purchased in 1917 for utilizing the exhaust steam from the dynamo engine for heating the feed water, was installed early in 1919. The economizers were repaired, new grates were installed in boilers Nos. 5 and 15, broken stay bolts were replaced in boilers Nos. 15 and 16, a large amount of feed-water piping was renewed and two boiler feed pumps were repaired. About 630 square feet of the concrete floor in the boiler room was renewed in front of the boilers and the drains in the engine room basement and the trestle supporting the railroad track over the coal pocket were repaired. All of the suction valves in engine No. 12 were equipped with new springs; a large amount of general work was done on this engine and on engine No. 6 and the 6-inch steam main was anchored to the engine room wall to prevent vibration. An independent air pump, purchased for use in connection with all of the engines, was received late in the year and is now being installed.

Six steel one cubic yard capacity V body tip cars, purchased to facilitate the removal of all of the ashes during the first watch, were received just before the end of the year, but the new arrangement has not been given a trial.

The cast-iron cap on the chimney, which was badly corroded by the flue gases, was replaced with a reinforced concrete cap covered with $\frac{1}{4}$ -inch sheet lead. New lightning rod tips were installed and the chimney was repointed for a distance of 20 feet below the cap.

At these stations 25,765,740,000 gallons of water were pumped during the year, of which 15,167,850,000 gallons were supplied to the southern high-service district and the southern extra high-service pumping station, and the remainder, 10,597,890,000 gallons, were supplied to the southern low-service district. The average daily pumpage was 41,555,800 gallons for the high service and 29,035,300 gallons for the low service, with a maximum of 51,550,500 gallons on December 18 for the high service and 52,414,300 gallons on January 13 for the low service.

The pumping statistics for these stations for 1919 are as follows: —

Station No. 1.
Pumpage and Duty.

	Engines Nos. 1 and 2.	Engine No. 3.	Engine No. 4.	Totals.
Pumping capacity (million gallons per day),	16	20	30	66
Pumping time (engine hours),	4,008.00	202.90	703.50	4,914.40
Pumpage, total (million gallons), ¹	1,365.57	165.96	926.23	2,457.76
Pumpage, average daily (gallons), ¹	3,741,300	454,700	2,537,600	6,733,600
Lift, average (feet),	133.06	128.05	125.08	129.71
Coal used: —				
Bituminous (pounds),	—	—	—	3,241,896
Anthracite screenings (pounds),	—	—	—	1,202,489
Duty, average (foot-pounds per 100 pounds coal),	—	—	—	59,750,000

¹ Corrected for slip.

Cost of Pumping.

	Totals.	Per Million Gallons.	Per Million Foot- Gallons.	Electric Equiva- lent per Kilowatt Hour.
Labor (operation and superintendence),	\$16,940 31	\$6 89	Cents. 5.31	Cents. 1.69
Fuel,	13,730 70	5 59	4.31	1.37
Repairs,	10,171 46	4 14	3.19	1.02
Oil, waste and packing,	698 81	28	.22	.07
Miscellaneous supplies,	1,015 59	41	.32	.10
Totals,	\$42,556 87	\$17 31	13.35	4.25
Administration, general supervision, interest and sinking fund.	33,798 83	13 75	10.60	3.38

*Station No. 2.**Pumpage and Duty.*

	Engines Nos. 5, 6 and 7.	Engine No. 12.	Totals.
Pumping capacity (million gallons per day),	105	40	145
Pumping time (engine hours),	10,204.00	8,121.10	18,325.10
Pumpage, total (million gallons), ¹	10,597.89	12,710.09	23,307.98
Pumpage, average daily (gallons), ¹	29,035,300	34,822,200	63,857,500
Lift, average (feet),	29.70	122.48	80.29
Coal used: —			
Bituminous (pounds),	—	—	9,702,307
Anthracite screenings (pounds),	—	—	3,496,834
Duty, average (foot-pounds per 100 pounds coal), . . .	—	—	118,110,000

¹ Corrected for slip.*Cost of Pumping.*

	Totals.	Per Million Gallons.	Per Million Foot- gallons.	Electric Equiva- lent per Kilowatt Hour.
Labor (operation and superintendence),	\$40,876 62	\$1 75	Cents. 2.18	Cents. .69
Fuel,	42,370 82	1 82	2.26	.72
Repairs,	17,040 97	73	.91	.29
Oil, waste and packing,	1,595 56	07	.09	.03
Miscellaneous supplies,	1,591 54	07	.09	.03
Totals,	\$103,475 51	\$4 44	5.53	1.76
Administration, general supervision, interest and sinking fund.	35,607 56	1 53	1.90	.61

As it was necessary to operate the boilers in one battery most of the time the duties of the individual engines were not determined except by special tests in April and December. The results of these tests are shown in the accompanying table.

*Duty Trials.**Engine No. 12.*

[24 hours' duration.]

	April 16-17.	April 21-22.	December 23-24.
Pumpage (million gallons), ¹	35.805	38.281	39.913
Lift average (feet),	121.750	122.190	123.920
Coal (pounds),	24,274.000 ²	28,515.000 ³	28,113.000 ⁴
Water evaporated per pound of coal—actual (pounds),	—	—	9.820
Water evaporated per pound of coal—from and at 212° (pounds),	—	—	10.460
Duty (million foot-pounds per 100 pounds of coal),	149.834	136.858	146.814

Engines Nos. 5, 6 and 7.⁵

[24 hours' duration.]

	April 23-24.	April 28-29.	December 30-31.
Pumpage (million gallons), ¹	24.570	26.619	49.727
Lift average (feet),	28.770	29.940	30.220
Coal (pounds),	8,503.000 ³	8,132.000 ²	12,911.000 ⁴
Water evaporated per pound of coal—actual (pounds),	9.360	9.570	9.820
Water evaporated per pound of coal—from and at 212° (pounds),	9.950	10.220	10.480
Duty (million foot-pounds per 100 pounds of coal),	69.354	81.777	97.116

Regular Service.

[7 days' duration.]

	ENGINE No. 12.	ENGINES NOS. 5, 6, 7 AND 12 AND ALL AUXILIARIES. ⁵	
	December 23-30.	December 23-30.	December 30-January 7.
Pumpage (million gallons), ¹	271.795	602.969	594.552
Lift average (feet),	124.050	71.980	74.920
Coal (pounds),	192,896.000 ⁴	303,361.000 ⁴	305,456.000 ⁴
Water evaporated per pound of coal—actual (pounds),	—	9.330	9.670
Duty (million foot-pounds per 100 pounds of coal),	145.855	119.487 ⁶	121.747 ⁶

¹ Plunger displacement.² Bituminous coal 100 per cent.³ Bituminous coal 60 per cent; anthracite screenings 40 per cent.⁴ Bituminous coal 70 per cent; anthracite screenings 30 per cent.⁵ Engines operating at from 50 to 90 per cent of full capacity during test.⁶ No allowance for heating and lighting.

Spot Pond Pumping Station.

At the Spot Pond pumping station engine No. 9 was out of service from November 8 to November 15 on account of a broken wrist plate, stud and steam valve rods on the high pressure valve gear.

In addition to the repairs on this engine considerable work was necessary on the fuel economizer, boilers and steam main.

A ventilating duct was erected from the top of the storage tank of the ash conveyor through the roof of the station to carry off the dust and steam.

All of the water supplied to the northern high-service district was pumped at this station. The pumps were operated about 12 hours per day, the boilers being maintained with banked fires when not in use.

The northern high-service pumping statistics for 1919 are as follows: —

*Spot Pond Station.**Pumpage and Duty.*

	Engine No. 8.	Engine No. 9.	Totals.
Pumping capacity (million gallons per day),	10	20	30
Pumping time (engine hours),	233.60	3,511.10	3,744.70
Pumpage, total (million gallons), ¹	95.69	2,964.11	3,059.80
Pumpage, average daily (gallons), ¹	262,000	8,121,000	8,383,000
Lift, average (feet),	122.64	132.93	132.60
Coal used: —			
Bituminous (pounds),	61,980	1,857,086	1,919,066
Anthracite screenings (pounds),	41,420	1,221,565	1,262,985
Duty, average (foot-pounds per 100 pounds coal),	94,540,000	106,610,000	106,220,000

¹ Corrected for slip.

Cost of Pumping.

	Totals.	Per Million Gallons.	Per Million Foot- gallons.	Electric Equiva- lent per Kilowatt Hour.
Labor (operation and superintendence),	\$12,957 59	\$4 23	Cents. 3.19	Cents. 1.02
Fuel,	9,956 77	3 25	2.45	.78
Repairs,	2,161 82	71	.54	.17
Oil, waste and packing,	576 15	19	.14	.04
Miscellaneous supplies,	570 70	19	.14	.04
Totals,	\$26,223 03	\$8 57	6.46	2.05
Administration, general supervision, interest and sinking fund.	16,567 78	5 41	4.08	1.30

Arlington Pumping Station.

All of the water supplied to the northern extra high-service district during the year was pumped at the Arlington pumping station from the northern low-service mains. Only a few minor repairs have been necessary at this station during the year.

The northern extra high-service pumping statistics for 1919 are as follows:—

*Arlington Station.**Pumpage and Duty.*

	Engine No. 10.	Engine No. 11.	Engine No. 15.	Totals.
Pumping capacity (million gallons per day),	1.50	1.50	3	6
Pumping time (engine hours),	7,657.70	3.80	65.80	7,727.30
Pumpage, total (million gallons), ¹	306.80	.07	4.81	311.68
Pumpage, average daily (gallons), ¹	840,500	200	13,200	853,900
Lift, average (feet),	279.92	276.57	294.62	280.14
Coal used:—				
Bituminous (pounds),	699,639	241	24,055	723,935
Anthracite screenings (pounds),	665,396	239	540	666,175
Duty, average (foot-pounds per 100 pounds coal),	52,410,000	33,600,000	48,000,000	52,320,000

¹ Corrected for slip.

Cost of Pumping.

	Totals.	Per Million Gallons.	Per Million Foot- gallons.	Electric Equiva- lent per Kilowatt Hour.
Labor (operation and superintendence),	\$9,433 64	\$30 27	Cents. 10.80	Cents. 3.44
Fuel,	3,708 40	11 90	4 25	1.35
Repairs,	875 78	2 81	1.00	.32
Oil, waste and packing,	138 60	44	.16	.05
Miscellaneous supplies,	322 28	1 03	.37	.12
Totals,	\$14,478 70	\$46 45	16.58	5.28
Administration, general supervision, interest and sinking fund.	5,989 02	19 22	6.86	2.18

Hyde Park Pumping Station.

All of the water supplied to the southern extra high-service district was repumped at the Hyde Park pumping station from the southern high-service mains, the pumps being operated about 11 hours per day, the boilers being maintained with banked fires when not in use. The cross head and connecting rod boxes on engine No. 13 were refitted and the pump valves were turned down.

The southern extra high-service pumping statistics for 1919 are as follows:—

*Hyde Park Station.**Pumpage and Duty.*

	Engine No. 13.	Engine No. 14.	Totals.
Pumping capacity (million gallons per day),	3	3	6
Pumping time (engine hours),	3,153.50	1,106.60	4,260.10
Pumpage, total (million gallons), ¹	190.81	65.45	256.26
Pumpage, average daily (gallons), ¹	522,800	179,300	702,100
Lift, average (feet),	139.28	138.65	139.12
Coal used:—			
Bituminous (pounds),	200,475	70,417	270,892
Anthracite screenings (pounds),	293,158	104,310	397,468
Duty, average (foot-pounds per 100 pounds coal), . . .	41,850,000	43,260,000	44,430,000

¹ Corrected for slip.

Cost of Pumping.

	Totals.	Per Million Gallons.	Per Million Foot- gallons.	Electric Equiva- lent per Kilowatt Hour.
Labor (operation and superintendence),	\$8,759 67	\$34 18	Cents. 24.57	Cents. 7.82
Fuel,	1,754 52	6 85	4.92	1.57
Repairs,	719 24	2 81	2.02	.64
Oil, waste and packing,	378 29	1 47	1.06	.34
Miscellaneous supplies,	377 19	1 47	1.06	.34
Totals,	\$11,988 91	\$46 78	33.63	10.71
Administration, general supervision, interest and sinking fund.	5,179 39	20 21	14.53	4.63

DISTRIBUTION RESERVOIRS.

The locations, elevations and capacities of the distribution reservoirs of the Metropolitan Water Works are shown by the following table:—

DISTRIBUTION RESERVOIRS AND LOCATIONS.	Elevation of High Water. ¹	Capacity in Gallons.
Low Service:—		
Spot Pond, Stoneham and Medford,	163.00	1,791,700,000
Chestnut Hill Reservoir, Brighton District of Boston,	134.00	300,000,000
Weston Reservoir, Weston,	200.00	200,000,000
Mystic Reservoir, Medford,	157.00	26,200,000
Northern High Service:—		
Fells Reservoir, Stoneham,	271.00	41,400,000
Bear Hill Reservoir, Stoneham,	300.00	2,450,000
Northern Extra High Service:—		
Arlington Standpipe, Arlington,	442.00	550,000
Southern High Service:—		
Fisher Hill Reservoir, Brookline,	251.00	15,500,000
Waban Hill Reservoir, Newton,	264.50	13,500,000
Forbes Hill Reservoir, Quincy,	192.00	5,100,000
Forbes Hill Standpipe, Quincy,	251.00	330,000
Southern Extra High Service:—		
Bellevue Reservoir Steel Tank, West Roxbury District of Boston,	375.00	2,500,000
Total,	—	2,399,230,000

¹ Elevation in feet above Boston City Base.

By arrangement with the city of Chelsea a portion of the maintenance of its reservoir on Powder Horn Hill is assumed by the Metropolitan Water Works, and the reservoir is used when necessary in connection with the northern high-service supply. The reservoir has a capacity of 1,000,000 gallons with high water line at elevation 196.6. It was put into service January 11, the repairs to stop leakage, which were begun under very unfavorable conditions late in 1918, having been completed. As there was still some leakage from the reservoir it was shut off again on April 11 and in September further repairs were undertaken, which were completed October 20. The reservoir was filled on the following day and no further leakage has occurred. The reservoir was put into service again on November 25.

Weston Reservoir.

The inlet chamber and the screen chamber at the Weston Reservoir and the terminal chamber of the lower Weston Aqueduct were kept in good condition. The operation of the screens has required a large amount of attention. Riprap, beaches, lawns, walks, drives, drains, fences and grounds about the reservoir were given the necessary attention to keep them in good order.

Chestnut Hill, Fisher Hill and Waban Hill Reservoirs.

The gate-houses and screens and the shrubs, walks, drives, fences and grounds at the Chestnut Hill, Fisher Hill and Waban Hill reservoirs were cared for as usual.

At Chestnut Hill Reservoir, the driveway between the Bradlee and Lawrence basins was given a surface coat of fine stone and tarvia. The iron floor of the terminal chamber of the Sudbury Aqueduct and of effluent gate-house No. 2 were painted and the ceiling of the latter was varnished and the woodwork painted. New doors were provided at the entrance to effluent gate-house No. 1, the interior doors were painted, roof and windows were repaired and concrete posts were made for the proposed fence on Beacon Street at this place. Stalls and windows were repaired at the stable, the exterior and interior woodwork of the garage was painted and the cornice was waterproofed.

On account of the strike of a portion of the Boston police force a company of the State Guard was billeted in the stable at the Chestnut Hill Reservoir from September 11 to October 6.

Spot Pond, Fells and Bear Hill Reservoirs.

At Spot Pond and the Fells and Bear Hill reservoirs the gate-houses, walks, shrubs and grounds have received the usual care. Gates have been operated and screens have been cleaned as required. The interior and exterior woodwork at all gate-houses was painted and the weir at the outlet of the drainage system in Virginia Woods was repaired. The former Bottume house at Spot Pond has been occupied by the subforeman in charge of the labor forces since September 1.

Bellevue and Forbes Hill Reservoirs.

Bellevue Reservoir has been in service throughout the year, and the standpipe and tower have received the usual care. Forbes Hill Reservoir has been kept full of water for emergency use; the standpipe has been in service throughout the year. The outside of the lower plates of the stand-pipe and the woodwork of the tower and the iron stairs were painted. Some work has been done on the erection of a new fence on the southeasterly boundary line of the water works land.

Arlington and Mystic Reservoirs.

The Arlington standpipe has been in service throughout the year. It is very much in need of painting but as it is planned to replace the structure with a larger tank before long the painting of the existing tank has been deferred. The Mystic Reservoir was out of service until November 4 but was kept full for emergency use, except during July, August and September when the brick lining was being repaired. The stone coping, which had been thrown considerably out of line near the gate-house by frost, was set back on line. An iron fence 4 feet in height has been erected around the reservoir during the year. It is located just back of the coping stone about 2.5 feet from the water. The fence posts are 3-inch steel I beams with cast-iron ornamental caps; rails are 2-inch steel angles and the pickets are 1½-inch steel angles pointed at the top and spaced 6 inches apart. The fence, which is 1,833 feet in length, cost \$4,856 or \$2.65 per linear foot.

Mystic Lake, Conduit and Pumping Station.

These structures, which were acquired from the city of Boston in 1898 and have not been used since for water supply purposes, were given only such attention as necessary to keep them in repair. The discharge of the water from Mystic Lake at the wasteway at the dam was regulated so as to keep the water in the lake just below high-water line, except when it was drawn down in anticipation of large yields from the watershed, as at such times some storage is necessary for satisfactory regulation.

The American Radio & Research Corporation has occupied the old Mystic pumping station during the entire year manufacturing

material for the United States Government, permission having been granted for such occupancy until March 1, 1920.

Further repairs have been made at the house and barn located near the station.

Grounds at Arlington and Hyde Park Pumping Stations.

The lawns, shrubs, drives and fences at the Arlington and Hyde Park pumping stations were given the usual attention and are in good condition.

DISTRIBUTION PIPE LINES.

The length of distribution pipe lines owned and operated at the close of the year is 126.08 miles, an increase of 1.81 miles during the year. In connection with the maintenance of the pipe lines they have been regularly patrolled and the work of municipalities and public service corporations in the vicinity of the pipe lines has been inspected. The location of each valve chamber has been plainly stenciled on objects along the line so that valves can be readily found when desired. The valves have been kept in good working condition, the valve chambers were cleaned and the frames and covers were regulated to conform to the grades of the streets where necessary. The covers over important valves were covered with salt during cold weather to keep them free from ice.

Low-service Mains.

The work of raising the two 24-inch low-service mains, located between Condor Street and Chelsea Creek in East Boston, which was undertaken by the Boston & Lockport Block Company in 1918, in connection with the enlargement of its plant on account of war work, has been practically completed during the year. The final connection on the easterly line was made January 13 and the line put into service. The work of filling under and around the mains was resumed in June and is now practically completed.

The 16-inch Venturi meter tube in the by-pass around the 24-inch valve near the gate-house at Mystic Reservoir was removed early in November and the branches were capped.

Pipe Bridges.

A new top was placed on the wooden box around the steel pipe at the Stony Brook crossing in Hyde Park Avenue in West Roxbury and the sides of the box were repaired. The roof and floor of the pipe box over the Boston & Maine Railroad at Walnut Street, Somerville, were removed for extensive repairs, and minor repairs were made on roof and sides of the pipe box at the Chelsea North Bridge, to the floor of the pipe boxes over the Boston & Maine Railroad at College Avenue in Medford and at Webster Avenue in Somerville.

Pipe Yards.

The side track at the Chestnut Hill pipe yard was repaired for a length of 1,550 feet, by contract, in August, at a cost of \$1,180. The roadbed was regraded and the rails were lined up, using 324 new ties cut by water works employees on the Wachusett Reservoir lands. Minor repairs were made at the yard office, the carpenter shop and the shed, and the water service pipes were renewed at the office and blacksmith shop.

At the Glenwood pipe yard minor repairs were made in the interior of the office building and the steam heating plant is being renewed. The platform of the yard scale was relaid with 3-inch hard pine plank in October and a new derrick is being installed.

Meters, Regulating Valves and Recording Pressure Gages.

During the year two Venturi meters were installed on the low-service mains in Washington Street, Brookline. The Venturi meters on the low-service relief pipe at Chestnut Hill Reservoir and on the by-pass at Mystic Reservoir were removed. On account of unauthorized use of water from the Commercial Street fire main in Malden the city was required to set a 12-inch x 6-inch Hersey detector meter at the connection of the fire main with the Metropolitan Water Works northern high-service main in Pleasant Street. This meter was placed in service August 1.

At the close of the year there were 69 Venturi meters varying in size from 6 inches to 60 inches in diameter, 8 Hersey detector meters, 4 Hersey disc meters and 1 Hersey torrent meter owned and operated by the Metropolitan Water Works and connected with the distribution mains, which, with the exception of 9 of the Venturi meters,

1 detector meter and 1 disc meter, were in use for measuring the water supplied to the various municipalities in the Metropolitan Water District. There were also 3 disc meters, 1 detector meter, 3 Union meters and 1 Crown meter connected with the distribution mains but not owned by the Metropolitan Water Works.

Three men and a light auto truck are now used in the operation and care of the meters which are visited regularly twice each week. They are also given such additional attention as is necessary to keep them in repair and operating satisfactorily.

The 8 pressure regulating valves installed in the distribution mains for reducing the pressure of water supplied to portions of Chelsea, East Boston and Hyde Park and to Nahant, Revere, Swampscott and Winthrop have received the usual attention and have controlled the water pressures in a satisfactory manner.

Recording pressure gages have been maintained at 20 stations on the Metropolitan Water Works, and the table in Appendix No. 2, showing the elevation of the hydraulic grade line at 18 of these stations, has been prepared from the charts.

Breaks and Leaks.

A crack 1.3 feet in length was discovered in the 16-inch northern high-service main in Beach Street, near Broadway, Revere, on May 29. The cost of repairing this break was \$62.11.

In October and November six joint leaks were repaired in the westerly 36-inch pipe line under the Mystic River at the Wellington Bridge. It was necessary to employ a diver for this work, which cost \$1,052.70.

In December three joint leaks were repaired in the easterly 36-inch main under the Charles River at Magazine Street, Cambridge. This work was also done by a diver and cost \$1,795.90.

There were 38 minor joint leaks repaired in the distribution mains during the year, of which 7 were defective wooden joints which were repaired at a cost of \$184.02, and the remaining 31 were defective lead joints which were repaired at a cost of \$866.51.

Emergency Pipe Line Service.

The two $\frac{3}{4}$ -ton auto trucks, equipped with special bodies and gate operating attachments, put into service in 1917 for operating valves quickly in case of emergency, have been in service during the entire

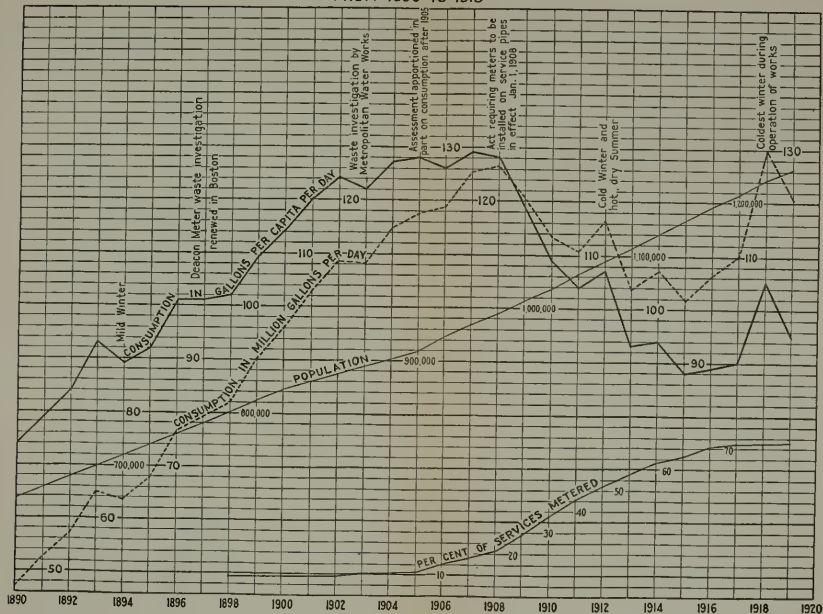
year. One of the trucks is stationed at the Chestnut Hill pipe yard in Brighton for use on the southern portion of the distribution pipe system and the other is stationed at the Glenwood pipe yard in Medford for use on the northern portion of the pipe system. Men are kept on duty ready to operate the trucks in case of emergency at any time during the day or night.

CONSUMPTION OF WATER.

The total quantity of water furnished to the 18 municipalities supplied from the Metropolitan Water Works during the year 1919, as measured by the water works meters, is 44,016,611,000 gallons, which is equivalent to an average consumption of 120,593,500 gallons per day. On the basis of an estimated population of 1,267,080 this is equivalent to a consumption of 95 gallons per capita per day, which is a reduction of 10 gallons per capita per day, or 9.5 per cent, from the per capita consumption for 1918, and is attributed to the reduced industrial activity resulting from the termination of the war and to the mild winter. With a return to normal conditions and the resumption of the work of installing meters on the service pipes, which was interrupted to a considerable extent by the war, a further reduction in the per capita consumption is anticipated for the future. It is of interest to note on the accompanying diagram that as a result of installing meters on service pipes the per capita consumption is now 7 per cent less than in 1898 when the Metropolitan Water Works were put into service 22 years ago.

The average daily consumption of water in each of the municipalities supplied from the Metropolitan Water Works during 1918 and 1919, as measured by the Metropolitan Water Works meters, is as follows: —

POPULATION, CONSUMPTION OF WATER AND PER CENT OF SERVICES METERED
IN THE
METROPOLITAN WATER DISTRICT
AS SUPPLIED IN 1919
FROM 1890 TO 1919



	Estimated Popula- tion, 1919.	AVERAGE DAILY CONSUMPTION.				
		1918.		1919.		Decrease in Gallons.
		Gallons.	Gallons per Capita.	Gallons.	Gallons per Capita.	
Arlington,	17,530	1,290,300	76	1,085,700	62	204,600
Belmont,	9,710	577,700	62	564,000	58	13,700
Boston,	804,140	94,634,000	120	89,652,400	111	4,981,600
Chelsea,	48,840	3,501,200	74	3,158,400	65	342,800
Everett,	41,610	3,365,800	83	2,886,700	69	479,100
Lexington,	6,020	494,600	84	389,200	65	105,400
Malden,	53,150	3,254,700	62	2,682,800	50	571,900
Medford,	35,860	2,161,200	62	1,688,500	47	472,700
Melrose,	18,170	1,180,600	66	1,057,100	58	123,500
Milton,	9,450	434,500	47	401,300	42	33,200
Nahant,	1,570	228,200	149	186,900	119	41,300
Quincy,	45,280	4,632,100	105	4,550,100	100	82,000
Revere,	30,640	1,975,500	67	1,780,700	58	194,800
Somerville,	94,800	7,433,200	80	6,541,500	69	891,700
Stoneham,	7,840	617,700	80	602,400	77	15,300
Swampscott,	8,160	606,100	76	570,900	70	35,200
Watertown,	19,140	2,434,700	131	2,002,900	105	431,800
Winthrop,	15,170	941,900	65	792,000	52	149,900
District,	1,267,080	129,764,000	105	120,593,500	95	9,170,500

This table shows that there was a decrease in consumption in 1919 as compared with the previous year in every city and town in the district. The consumption by districts in 1919 as compared with the consumption in these districts during the previous year is as follows:—

	Gallons per Day, 1919.	DECREASE FROM 1918.	
		Gallons per Day.	Percent- age.
Southern low-service district, embracing the low-service district of Boston, with the exception of Charlestown and East Boston, . .	42,407,800	4,430,200	9.46
Northern low-service district, embracing the low-service districts of Somerville, Chelsea, Malden, Medford, Everett, Arlington, Charlestown and East Boston,	24,677,900	1,750,400	6.62
Southern high-service district, embracing Quincy and Watertown, the high-service districts of Boston, and portions of Belmont and Milton,	43,059,400	1,572,400	3.52
Northern high-service district, embracing Melrose, Revere, Winthrop, Swampscott, Nahant and Stoneham, and the high-service districts of Somerville, Chelsea, Malden, Medford, Everett and East Boston,	8,893,500	1,108,000	11.08
Southern extra high-service district, embracing the higher portions of Hyde Park, Milton and West Roxbury,	668,400	125,200	15.78
Northern extra high-service district, embracing Lexington and the higher portions of Arlington and Belmont,	886,500	184,300	17.21
Totals,	120,593,500	9,170,500	7.07

Installation of Meters on Service Pipes.

Information regarding the installation of meters on service pipes by the municipalities supplied with water from the Metropolitan Water Works is given in the accompanying table.

CITY or TOWN.	Services in Use Dec. 31, 1907.	Services equipped with Meters Dec. 31, 1907.	Number of Meters required to be set on Old Services Each Year.	Old Services in Use Dec. 31, 1919.	Old Services equipped with Meters Dec. 31, 1919.	Meters Set on Old Services 1908-1919, inclusive.	Number of Meters required to be set on Old Services 1908-1919, inclusive.	New Services installed and in Use Dec. 31, 1919. ¹	New Services equipped with Meters Dec. 31, 1919. ¹	Total Services in Use Dec. 31, 1919.	Total Services equipped with Meters Dec. 31, 1919.	Per Cent of Services metered Dec. 31, 1919.
Arlington,	1,929	835	55	1,804	1,804	969	660	1,442	1,442	3,246	3,246	100.00
Bedmont,	792	792	—	754	754	—	—	1,040	1,040	1,794	1,794	100.00
Boston,	93,942	5,190	4,276	90,029	50,434	45,241	42,556 ²	15,949	13,644	105,978	64,078	60.46
Chelsea,	6,603	1,792	140	3,374 ³	3,348	1,556	1,680	1,869	1,862	5,210	5,210	99.37
Dorchester,	5,161	1,116	252	5,152	3,140	3,024	3,024	941	941	6,093	4,081	66.98
Lexington,	7,730	80	32	7,746	7,730	650	384	580	580	1,310	1,310	98.79
Malden,	7,655	6,780	14	6,925	6,716	—	384	1,304	1,283	8,229	7,909	97.21
Medford,	4,978	1,582	179	4,071	4,071	3,489	2,148	2,700	2,700	6,771	6,771	100.00
Methuën,	3,429	1,658	119	3,398	3,353	2,295	1,428	1,033	1,033	4,431	4,386	98.98
Milton,	1,285	1,285	—	1,283	1,283	—	—	887	887	2,170	2,170	100.00
Nahant,	410	90	16	410	304	214	192	356	264	766	568	74.15
Quincy,	6,091	1,480	230	5,892	5,303	3,823	2,760	4,939	4,534	10,831	9,837	90.82
Revere,	2,875	158	138	2,875	1,986	1,828	1,656	1,896	1,813	4,771	3,709	79.63
Somerville,	11,662	3,446	411	11,432	8,375	4,929	4,932	2,092	2,075	13,524	10,450	77.27
Stoughton,	1,331	30	65	1,320	1,318	1,288	780	354	354	1,674	1,672	99.88
Swampscott,	1,307	892	21	1,305	1,305	413	252	683	683	1,988	1,988	100.00
Waltham,	1,886	1,886	—	1,886	1,886	—	—	1,469	1,469	3,355	3,355	100.00
Winthrop,	2,074	70	100	2,033	2,019	1,949	1,500	964	964	2,997	2,983	99.53
Totals,	152,940	26,562	6,048	144,689	98,129	71,607	63,690	40,498	37,588	185,187	135,697	73.28

¹ The number of new services installed and the number of new services equipped with meters do not always agree for the reason that service pipes are installed but meters are not set until the buildings are permanently occupied.

² Boston: Number of meters required to be set each year on old services, 4,438 for 1908, 1909 and 1910; reduced to 4,225 in 1911 on account of reduction in number of old services and increased to 4,276 after 1911 on account of unmetered services acquired by the annexation of Hyde Park. Boston exempt from setting meters on old services in 1917 and 1918. (Chapter 269, Special Acts of 1917, and Chapter 45, Special Acts of 1918.)

³ Chelsea: 2,810 services destroyed during conflagration in April, 1908; 987 metered services remained after conflagration.

⁴ Allowance included for services abandoned.

During 1919 2,191 service pipes and 2,965 meters were installed in the municipalities supplied from the Metropolitan Water Works, and at the close of the year 185,187 service pipes and 135,697 meters were in use; 73.28 per cent of all the service pipes had been provided with meters; in six of the municipalities all of the service pipes were equipped with meters, and in three other municipalities over 99 per cent of the service pipes were equipped with meters.

WATER SUPPLIED OUTSIDE OF METROPOLITAN WATER DISTRICT.

During the year 441,943,000 gallons of water were supplied from the Metropolitan Water Works for use outside the Metropolitan Water District as follows:—

PLACES SUPPLIED.	Total Quantity (Gallons).	Average Quantity (Gallons per Day).	Number of Days on which Water was supplied.	Amounts charged for Water supplied.
Westborough State Hospital,	64,398,000	176,400	365	\$1,931 94
Town of Framingham:—				
From Sudbury Aqueduct,	171,300,000	471,901	363	4,111 20
From Filter-gallery at Farm Pond,	175,500,000	480,822	365	336 58
United States Government:—				
Peddock's Island,	20,279,000	55,600	365	1,272 43
Portion of town of Saugus,	10,466,000	28,700	365	580 00

QUALITY OF THE WATER.

The yearly average results of the chemical analyses, made by the State Department of Health since 1892, and of the biological and bacteriological examinations, made in the Metropolitan Water Works laboratory, of water from service taps in Boston since 1898, are given in tables in Appendix No. 2.

ENGINEERING.

In connection with the maintenance of the works the engineering force has made plans, estimates and reports for various projects and improvements; has made record plans of water works, lands and structures and surveys and plans for land purchases and takings; has tested meters; made photographs, blue prints and analyses of coal and oil; calculated yields of watersheds; made current meter

gagings; kept hydraulic and meteorological records; summarized power station and pumping station records; cared for the recording pressure gages and supervised various water works operations.

Appended to this report are tables giving additional information relating to the operations of the Metropolitan Water Works for the year 1919 and the usual water works statistics.

Respectfully submitted,

WILLIAM E. FOSS,

Director and Chief Engineer.

Boston, January 2, 1920.

REPORT OF DIRECTOR AND CHIEF ENGINEER OF SEWERAGE DIVISION.

JAMES A. BAILEY, *Commissioner, Metropolitan District Commission.*

The following report of the operations of the Metropolitan Sewerage Works for the year ending December 31, 1919, is respectfully submitted:—

ORGANIZATION.

The Chief Engineer has charge of the design and construction of all new works, and of the maintenance and operation of all the works controlled by the Metropolitan District Commission for removing sewage from the twenty-six municipalities which comprise the Metropolitan Sewerage districts.

The following assistants have been employed during the year:—

Henry T. Stiff,	Senior Assistant Engineer, in charge of office and drafting room and of the construction work.
Clarence A. Moore,	Assistant Engineer, in charge of maintenance studies and records and of construction work on the North Metropolitan System.
Arthur F. F. Haskell,	Assistant Engineer, in charge of survey and field work in connection with the Wellesley Extension construction.
Ralph W. Loud,	Assistant Engineer, in charge of survey and field work in connection with the Reading Extension construction.
George W. Wood,	Assistant Engineer, on Reading Extension.

In addition to the above, the number of engineering and other assistants employed during the year was 16, which includes 2 superintendents, 2 instrumentmen, 4 inspectors, 2 draftsmen, 4 rodmen and engineering assistants and 2 stenographers.

METROPOLITAN SEWERAGE DISTRICTS.

AREAS AND POPULATIONS.

During the year no changes have been made in the extent of the Metropolitan Sewerage districts.

The populations of the districts, as given in the following table, are based on the census of 1915.

Table showing Ultimate Contributing Areas and Present Estimated Populations within the Metropolitan Sewerage Districts, as of December 31, 1919.

CITY OR TOWN.		Area (Square Miles).	Estimated Population.
North Metropolitan District.	Arlington,	5.20	17,840
	Belmont,	4.66	9,910
	Boston (portions of),	3.45	112,520
	Cambridge,	6.11	114,120
	Chelsea,	2.24	49,480
	Everett,	3.34	42,070
	Lexington, ¹	5.11	4,500
	Malden,	5.07	53,650
	Medford,	8.35	36,480
	Melrose,	3.73	18,330
	Reading,	9.82	8,040
	Revere,	5.86	31,280
	Somerville,	3.96	95,740
	Stoneham,	5.50	7,880
	Wakefield,	7.65	14,030
	Winchester,	5.95	11,040
South Metropolitan District.	Winthrop,	1.61	15,460
	Woburn,	12.71	17,160
		100.32	659,530
	Boston (portions of),	24.96	298,160
	Brookline,	6.81	38,350
	Dedham, ¹	9.40	12,430
	Milton,	12.59	9,550
	Newton,	16.88	46,330
	Quincy,	12.56	45,820
	Waltham,	13.63	32,570
	Watertown,	4.04	19,440
	Wellesley,	9.89	7,450
		110.76	510,100
Totals,		211.08	1,169,630

¹ Part of town.

METROPOLITAN SEWERS.

SEWERS PURCHASED AND CONSTRUCTED AND THEIR CONNECTIONS.

During the year there have been built 1.680 miles of Metropolitan sewers within the sewerage districts, so that there are now 114.920 miles of Metropolitan sewers. Of this total, 9.642 miles of sewers, with the Quincy pumping station, have been purchased from cities and towns of the districts. The remaining 105.278 miles of sewers and other works have been constructed by the Metropolitan boards.

The locations, lengths and sizes of these sewers are given in the following tables, together with other data referring to the public and special connections with the systems:—

NORTH METROPOLITAN SEWERAGE SYSTEM.

Location, Length and Sizes of Sewers, with Public and Special Connections.

CITY OR TOWN.	Size of Sewers.	Length in Miles.	Public Connections, December 31, 1919.	SPECIAL CONNECTIONS.	
				Character or Location of Connection.	Number in Operation.
Boston:—					
Deer Island,	4' 0" to 9' 0",	1.653	4	-	-
East Boston,	9' 0" to 1' 0",	5.467	25	Shoe factory,	1
Charlestown,	6' 7"×7' 5" to 1' 0",	3.292	15	Middlebrook	1
				Co.,	1
Winthrop,	9' 0",	2.864	13	Navy Yard,	8
				Private building,	1
				Club house,	1
				Fire Department Station,	1
				Private building,	1
Chelsea,	8' 4"×9' 2" to 15",	5.230	13	Bakery,	1
				Rendering works,	1
				Metropolitan Water Works	
				blow-off,	1
				Chelsea Water Works blow-	
Everett,	8' 2"×8' 10" to 4' 8"×5' 1",	2.925	8	offs,	2
				Naval Hospital,	1
				Metropolitan Water Works	
				blow-off,	1
				Cameron Appliance Co.,	1
				Shultz-Goodwin Co.,	1
				Andrews-Wasgatt Co.,	1
Lexington,	-	-	1	National Metallic Bed Co.,	1
				Linoide Co.,	1
				Factory,	2
Malden,	4' 6"×4' 10" to 1' 0",	5.844 ¹	34	New England Structural Co.,	1
				Metropolitan Water Works	
				blow-off,	1
				Private buildings,	188 ²

¹ Includes 1.84 miles of sewer purchased from the city of Malden.

² Mostly buildings connected with sewers formerly belonging to city of Malden but later purchased by the Metropolitan Sewerage Commission in accordance with Chapter 215 of the Acts of 1898 and by the Metropolitan Water and Sewerage Board in accordance with Chapter 512 of the Acts of 1911 and made parts of the North Metropolitan Sewerage System.

NORTH METROPOLITAN SEWERAGE SYSTEM — *Concluded.**Location, Length and Sizes of Sewers, with Public and Special Connections*
— *Concluded.*

CITY OR TOWN.	Size of Sewers.	Length in Miles.	Public Connections, December 31, 1919.	SPECIAL CONNECTIONS.	
				Character or Location of Connection.	Number in operation.
Melrose,	4' 6"×4' 10" to 10", . . .	6.099 ¹	39	Private buildings,	116 ²
				Factory,	1
				Railroad station,	1
				Park Department bathhouse,	1
				Harvard dormitories,	2
				Slaughterhouse,	1
				City Hospital,	3
				Street railway machine shop,	1
				Private building,	1
				Factory building,	1
				Tannery,	1
				Slaughterhouses (3),	1
				Car-house,	1
				Somerville Water Works blow-off,	1
				Street railway power house,	1
				Stable,	1
				Rendering works,	1
				Railroad scale pit,	1
				Private building,	1
				Armory building,	1
				Private buildings,	9
				Stable,	1
				Police substation,	1
				Tanneries,	6
				Private buildings,	9
				Gelatine factory,	1
				Watch-hand factory,	1
				Stable,	1
				Railroad station,	1
				Felt works,	1
				Town Hall,	1
				Bay State Saw & Tool Co.,	1
				Whitney Machine Co.,	1
Stoneham,	1' 8" to 10",	1.078	4	—	—
Woburn,	1' 10"×2' 4" to 1' 3",	1.040	3	Glue factory,	1
				Private buildings,	161 ⁴
				Railroad station,	1
				Car-house,	3
				Post office,	1
Arlington,	1' 6" to 10",	3.520 ³	43	—	—
Belmont, ⁵	—	—	3	—	—
Wakefield,	3' 0" to 2' 0"×2' 3",	0.258	1	—	—
Revere,	4' 0" to 15",	0.136	3	—	—
Reading,	—	—	—	—	—
		65.375 ⁶	318		557

¹ Includes .736 of a mile of sewer purchased from the city of Melrose.² Mostly buildings connected with a sewer formerly belonging to the city of Melrose but later purchased by the Metropolitan Sewerage Commission in accordance with Chapter 414 of the Acts of 1896 and with a sewer extension built in accordance with Chapter 436 of the Acts of 1897 by the Metropolitan Sewerage Commission as an outlet for part of the town of Stoneham and made parts of the North Metropolitan Sewerage System.³ Includes 2.631 miles of sewer purchased from the town of Arlington.⁴ Mostly buildings connected with a sewer formerly belonging to the town of Arlington but later purchased by the Metropolitan Sewerage Commission in accordance with Chapter 520 of the Acts of 1897 and made a part of the North Metropolitan Sewerage System.⁵ The Metropolitan sewer extends but a few feet into the town of Belmont.⁶ Includes 2.787 miles of Mystic Valley sewer in Medford and Winchester, running parallel with the Metropolitan sewer.

SOUTH METROPOLITAN SEWERAGE SYSTEM.

Location, Length and Sizes of Sewers, with Public and Special Connections.

CITY OR TOWN.	Size of Sewers.	Length in Miles.	Public Connections, December 31, 1919.	SPECIAL CONNECTIONS.	
				Character or Location of Connection.	Number in Operation.
Boston:—					
Back Bay, . . .	6' 6" to 3' 9", . . .	1.500 ¹	16	Tufts Medical School, . . .	1
				Private house, . . .	1
				Administration Building, . . .	1
				Boston Park Department, . . .	1
				Simmons College buildings, . . .	1
Brighton, . . .	5' 9"×6' 0" to 12", . . .	6.010 ²	15	Art Museum, . . .	2
				Abattoir, . . .	3
				Chocolate works, . . .	2
				Machine shop, . . .	1
Dorchester, . . .	3'×4' to 2' 6"×2' 7", . . .	2.870 ³	13	Paper Mill, . . .	1
				Private buildings, . . .	3
				Edison Electric Company Station, . . .	1
Hyde Park, . . .	10' 7"×11' 7" to 4' 0"×4' 1", . . .	4.527	18	Mattapan Paper Mills, . . .	1
				Private buildings, . . .	2
Roxbury, . . .	6' 6"×7' to 4' 0", . . .	1.430	—	Fairview Cemetery buildings, . . .	1
West Roxbury, . . .	9' 3"×10' 2" to 12", . . .	7.643	16	Caledonia Grove buildings, . . .	1
				Parental School, . . .	1
Brookline, . . .	6' 6"×7' 0" to 8", . . .	2.540 ⁴	12	Lutheran Evangelical Church, . . .	1
Dedham, . . .	4'×4' 1" to 2' 9"×3', . . .	3.272	7	Private buildings, . . .	4
Hull, ⁵ . . .	60" pipe, . . .	0.750	—	Private buildings, . . .	2
Milton, . . .	11'×12' to 8', . . .	3.600	23	Dedham Carpet Mills, . . .	1
Newton, . . .	4' 2"×4' 9" to 1' 3", . . .	2.911	8	Private buildings, . . .	2
				Private houses, . . .	7
Quincy, . . .	11' 3"×12' 6" to 24" pipe, . . .	6.845	14	Metropolitan Water Works blow-off, . . .	1
Waltham, . . .	3' 6"×4' 0", . . .	0.001	1	Squantum schoolhouse, . . .	1
Watertown, . . .	4' 2"×4' 9" to 12", . . .	0.750 ⁵	5	Factories, . . .	2
				Stanley Motor Carriage Co., . . .	1
Needham, ⁶ . . .	2' 0"×2' 3" to 2' 3"×2' 6", . . .	4.896	—	Knights of Pythias building, . . .	1
Wellesley, ⁷ . . .	— . . .	—	—	— . . .	—
		49.545	148		46

¹ Includes .355 of a mile of sewer purchased from the city of Boston.² Includes .446 of a mile of pipe and concrete sewers built for the use of the city of Boston; also .026 of a mile of sewer purchased from the town of Watertown.³ Includes 1.24 miles of sewer purchased from the city of Boston.⁴ Includes .158 of a mile of pipe sewer built for the use of the town of Brookline.⁵ Includes .025 of a mile of sewer purchased from the town of Watertown.⁶ Hull and Needham are not parts of the Metropolitan Sewerage District.⁷ The Metropolitan sewer extends but a few feet into the town of Wellesley.

Information relating to areas, populations, local sewer connections and other data for the Metropolitan Sewerage districts appears in the following table:—

North Metropolitan Sewerage District.

Area (Square Miles).	Estimated Total Population.	Miles of Local Sewer connected.	Estimated Population contributing Sewage.	Ratio of Contributing Population to Total Population (Per Cent).	CONNECTIONS MADE WITH METRO- POLITAN SEWERS.	
					Public.	Special.
100.32	659,530	779.65	595,570	90.3	318	557

South Metropolitan Sewerage District.

110.76	510,100	666.43	407,410	79.9	148	46
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Both Metropolitan Sewerage Districts.

211.08	1,169,630	1,446.08	1,002,980	85.8	466	603
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Of the estimated gross population of 1,169,630 on December 31, 1919, 1,002,980, representing 85.8 per cent, were on that date contributing sewage to the Metropolitan sewers, through a total length of 1,446.08 miles of local sewers owned by the individual cities and towns of the districts.

These sewers are connected with the Metropolitan systems by 466 public and 603 special connections. During the current year there has been an increase of 13.68 miles of local sewers connected with the Metropolitan systems, and 3 public and 11 special connections have been added.

CONSTRUCTION.

NORTH METROPOLITAN SEWERAGE SYSTEM.

READING EXTENSION.

In the preliminary study of the Reading Extension of the North Metropolitan Sewerage System the Joint Board, to which the matter was referred by the Legislature of 1914, recommended that a tunnel should be built that would permit the town of Reading to discharge its sewage by gravity into the Metropolitan Sewerage System.

This report was made to the Legislature of 1915 and the matter was referred to the Legislature of 1916. The latter authorized the construction of the work under Chapter 159 of the General Acts of 1916 which carried an appropriation equal to the original estimate of cost.

The Metropolitan Water and Sewerage Board made effort to

place the work under contract in the autumn of 1916 and publicly solicited bids for the construction of the tunnel, but none were received. Later the Board invited proposals from three responsible contractors of Boston. These bids were so high that it was evident that the work could not be built within the appropriation and the matter was brought to the attention of the Legislature of 1919. Additional legislation was passed whereby the Metropolitan Water and Sewerage Board was authorized to construct works for the disposal of the sewage of the town of Reading by pumping it into the Metropolitan sewers. The construction work has been carried on during the year in accordance with this plan.

SECTION 76. — READING EXTENSION.

The contract with Bruno & Petitti for the construction of about 1,370 feet of 36-inch and 24-inch by 27-inch concrete sewer at the northerly end of Section 76 was mentioned in last year's report. Construction work was continued into this year and was completed May 24, 1919. From Station 29+00 to Station 36+00 the excavation was made in fine sand and considerable difficulty was encountered, because of the large amount of ground water.

SECTION 73. — READING EXTENSION.

This section extends from a point in Hill Street, Woburn, through private lands, entering the town of Stoneham and crossing the Stoneham branch of the Boston & Maine Railroad, other private lands, extending into and along Montvale Avenue, then through private land and crossing Lindenwood Road, then extending into private land, a total length of 3,600 feet. A contract for the building of this section was entered into by the Board, some particulars of which are as follows: —

Date of contract No. 146,	June 18, 1919.
Name of contractor,	Rendle-Stoddard Company.
Length of section,	3,600 feet.
Average depth of sewer trench,	7 feet.
Dimensions of pipe sewer,	15-inch and 18-inch.
Assistant Engineer in charge of construction,	Ralph W. Loud.

In passing through land of the Boston & Maine Railroad the sewer was built in tunnel. No difficulties were encountered, and work was completed on this section October 18, 1919.

SECTION 74. — READING EXTENSION.

This section extends from a point in land of Oriana Brown north-erly mostly through private lands, crossing Lindenwood Road, Wil- liams Street and Oak Street to a point in land owned jointly by Charles A. Owen and George E. Merrifield, a total distance of 3,165 feet. A contract for the construction of this section was entered into by the Board, some particulars of which are as follows: —

Date of contract No. 148,	September 17, 1919.
Name of contractor,	Rendle-Stoddard Company.
Length of section,	3,165 feet.
Average depth of excavation,	7 feet.
Dimensions of pipe sewer,	15-inch, 18-inch and 20-inch.
Assistant Engineer in charge of construction work,	Ralph W. Loud.

Fine wet sands were found from Station 19+00 to Station 26+00. No serious difficulties have been encountered. At the close of the year there had been constructed 2,600 feet of sewer on this section.

The pipe for these sections, which was furnished by the Board, consists of double-strength section Akron pipe.

Studies for a pumping station, to be located in Reading near the intersection of Summer Avenue and Elm Street, have been made, and plans and specifications for receiving reservoir, pump well and building foundations will be ready early in January, 1920.

It is expected that the extension will be ready for use during the coming year.

SOUTH METROPOLITAN SEWERAGE SYSTEM.

WELLESLEY EXTENSION.

The Wellesley Extension of the High-level sewer comprises Sections 98 to 106 inclusive. Of these sections, 98, 102, 103, 104, 105 and 106 are wholly completed and Section 99 is over one-half completed.

Contracts have been entered into by the Board for the completion of the balance of Section 99 and for Section 101. Section 100 has not yet been placed under contract.

SECTION 99 (ROCK TUNNEL). — WELLESLEY EXTENSION.

The contract for this work was described in last year's report. In the construction of the sewer a brick arch was substituted for

the concrete arch in the tunnel. This change was requested by the contractor and was allowed by the Board as it reduced the cost.

SECTION 99 (TRENCH AND RIVER CROSSING). — STATION 17+50
TO STATION 33+00. — WELLESLEY EXTENSION.

This part of Section 99 extends from a point in Jenney Lane in Dedham through private lands and across the Charles River, a distance of 1,550 feet. A contract for the completion of this portion of the section was entered into by the Board, some particulars of which are as follows: —

Date of contract No. 149,	September 29, 1919.
Name of contractor,	John P. Cavanagh Company.
Length of section,	1,550 feet.
Average depth of cut in trench,	12 feet.
Dimensions of concrete sewer,	33-inch by 36-inch.
Assistant Engineer in charge of construction work,	Arthur F. F. Haskell.

Work was begun on this section October 2, 1919. At the end of the year about 50 feet of trench had been excavated and 10 feet of concrete sewer had been built. The material excavated thus far is boulder-clay and gravel. No serious difficulties have been encountered. A small amount of ground water has been found.

SECTION 101. — WELLESLEY EXTENSION.

This section extends from Common Street in Dedham along the southerly side of Charles River through private lands and crosses Dedham Avenue, private land and Charles River to a point in the town of Needham. The total length is 3,840 feet. A contract for the construction of this section was entered into by the Board, some particulars of which are as follows: —

Date of contract No. 145,	September 17, 1919.
Name of contractor,	Rendle-Stoddard Company.
Length of section,	3,840 feet.
Average depth of sewer in trench,	8 feet.
Dimensions of concrete sewer,	33-inch by 36-inch.
Dimensions of cast-iron siphon (2 lines under Charles River),	16 inches.
Assistant Engineer in charge of construction,	Arthur F. F. Haskell.

By permission of the Board the contractor was allowed to complete other work for the Board before starting on this section. This was done because of the scarcity of labor. No sewer has been constructed to date on this section.

MAINTENANCE.

SCOPE OF WORK AND FORCE EMPLOYED.

The maintenance of the Metropolitan Sewerage System includes the operation of 7 pumping stations, the Nut Island screen-house and 114.920 miles of Metropolitan sewers, receiving the discharge from 1,446.08 miles of town and city sewers at 466 points, together with the care and study of inverted siphons under streams and in the harbor.

The permanent maintenance force at present includes 153 men, of whom 92 are employed on the North System and 61 on the South System. These are subdivided as follows: North Metropolitan System, 58 engineers and other employees in the pumping stations and 34 men, including foremen, on maintenance, care of sewer lines, buildings and grounds; South Metropolitan System, 36 engineers and other employees in the pumping stations and 25 men, including foremen, on maintenance, care of sewer lines, buildings and grounds.

The regular work of this department, in addition to the operation of the pumping stations, has consisted of routine work of cleaning and inspecting sewers and siphons, caring for tide gates, regulators and overflows, measuring flow in sewers, inspection of connections with the Metropolitan sewers, and the care of pumping stations and other buildings and grounds.

In addition to these regular duties other work has been done by the maintenance employees of this department as follows: —

DEER ISLAND PUMPING STATION.

The coal run at this station which extends from the end of the wharf to the coal bins was constructed in 1895. During the year considerable repair work has been necessary on this structure.

The pumping station, dwelling house and locker buildings on the Island were repainted outside. The interior of the pumping station was cleaned and repainted throughout.

Repairs were made on the salt water well for injection water lo-

cated on the beach. These consisted of the raising of the wall of the structure about 2 feet by means of a cast-iron ring having a diameter of 84 inches with a thickness of 2 inches and the construction of a new cover.

A Holly System for the return to the boilers of condensation was installed at this station thereby doing away with the pump unit which had been used for this purpose.

EAST BOSTON PUMPING STATION.

The lower bearing of the 12-inch shaft of pump No. 4 which formerly consisted of lignum-vitæ bearing surfaces was removed, and a new bearing designed with babbitted brass bearing surfaces was installed in its place.

A Holly System for the return to the boilers of condensation was installed at this station thereby doing away with the pump unit which had been used for this purpose.

The diaphragm located in the manhole of the siphon near this station was repaired. This formerly was supported by iron cables which have been replaced by $\frac{1}{2}$ -inch galvanized iron chains.

CHARLESTOWN PUMPING STATION.

The interior of this station was cleaned and repainted throughout. A Whitlock feed-water heater was installed at this station.

ALEWIFE BROOK PUMPING STATION.

Additional granolithic was laid in the yard of this station.

The interior of the pumping station was cleaned and repainted throughout.

WARD STREET PUMPING STATION.

On September 3, 1919, during a heavy storm period, the babbitt metal in one of the main boxes of engine No. 1 at this station partially melted, thereby disabling the engine. Repairs were completed and the engine was put into service on September 6, 1919.

A hoisting apparatus with an orange peel bucket having a capacity of 2 cubic feet was installed in the screen-house at this station for the purpose of removing the sand from the suction channel. This work had formerly been done by hand.

NUT ISLAND SCREEN-HOUSE.

The wharf and bridge at this station were refloored. A new coal pocket was constructed on the wharf with a capacity of 400 tons. This work was done with second-hand lumber which had been used on construction work.

GOVERNMENT USE OF OLD 24-INCH QUINCY FORCE MAIN.

The sewerage connection of the shipbuilding plant at Squantum, Quincy, with the 24-inch cast-iron force main in Squantum Street, has been in use during the year. The average discharge through the force main has been at the rate of about 125,000 gallons per 24 hours. This sewage is discharged through the Boston Main Drainage outfall works at Moon Island.

GASOLENE IN PUBLIC SEWERS.

The efforts to improve the condition of the Metropolitan sewers in regard to dangers resulting from the introduction of gasoline into the same have been successfully continued throughout the year.

An inspector has been employed in this department whose duty it is to visit existing garages and see that the separators are kept in proper condition, also to enforce the regulation concerning the installation of such separators at all newly constructed garages.

During the year 109 new garages and other establishments using gasoline have been connected with the local sewer systems which discharge into the Metropolitan sewers. While the presence of gasoline in the Metropolitan sewers is noted occasionally, the condition has been greatly improved.

The following tables show the particulars in regard to establishments known to be using gasoline and which are connected with the public sewerage systems of the different municipalities in the Metropolitan Sewerage Districts:—

NORTH METROPOLITAN SEWERAGE DISTRICT.

Table showing Number of Places where Gasolene is used connected with Public Sewers and Progress of Work of installing Separators to December 31, 1919.

CITY OR TOWN.	Number of Places connected with Sewer.	Number of Places originally having Acceptable Separators.	Number of Places where Changes have been made.	Number of New Garages built, 1919.
Arlington,	6	—	3	—
Belmont,	4	—	3	—
Boston: —				
Charlestown District,	25	—	19	3
East Boston District,	26	—	17	4
Cambridge, ¹	109	—	94	14
Chelsea,	24	—	18	2
Everett,	16	—	14	1
Lexington,	1	—	—	1
Malden,	23	—	20	2
Medford,	16	—	13	2
Melrose,	7	—	5	2
Revere,	12	—	3	3
Somerville,	52	8	32	11
Stoneham,	6	—	6	—
Wakefield,	6	—	6	—
Winchester,	14	—	14	—
Winthrop,	4	—	4	—
Woburn,	3	—	3	—
Reading, ²	—	—	—	—
Totals,	354	8	274	45

¹ Storer's garage; no separator.² Not yet connected with Metropolitan sewer.

SOUTH METROPOLITAN SEWERAGE DISTRICT.

Table showing Number of Places where Gasolene is used connected with Public Sewers and Progress of Work of installing Separators to December 31, 1919.

CITY OR TOWN.	Number of Places connected with Sewer.	Number of Places originally having Acceptable Separators.	Number of Places where Changes have been made.	Number of New Garages built, 1919.
Boston: —				
Hyde Park District,	15	—	8	1
West Roxbury District,	31	10	16	5
Back Bay District,	59	22	26	11
Brighton District,	61	22	28	11
Dorchester District,	41	20	11	10
Brookline,	77	9	54	14
Dedham,	3	3	—	—
Milton,	1	1	—	—
Newton,	46	18	23	5
Quincy,	17	—	15	2
Waltham,	10	5	1	4
Watertown,	17	3	13	1
Wellesley, ¹	—	—	—	—
Totals,	378	113	195	64

¹ Not yet connected with Metropolitan sewer.

DRAINAGE FROM TANNERIES, GELATINE AND GLUE WORKS IN WINCHESTER, WOBURN AND STONEHAM.

Four men and a foreman have been employed during a part of the year flushing and cleaning the Metropolitan sewers through the tannery districts in Winchester, Woburn and Stoneham.

All the tanneries and glue works of the district now have settling tanks of substantial size. This method of treatment has very greatly reduced the amount of sludge material entering the Metropolitan sewers.

The following table gives details of settling tanks introduced to date, showing the operations of same with the amount of sludge collected and removed: —

Table of Semi-fluid Sludge removed from Settling Basins at the Tanneries, Gelatine and Glue Works in Winchester, Woburn and Stoneham, Year ending December 31, 1919.

LOCATION OF BASIN.	Basin in Operation.	Inside Measurement of Basin (Feet).	Number of Times cleaned during Year.	Average Quantity Semi-fluid Sludge removed during Year (Cubic Yards).	Total Quantity Semi-fluid Sludge removed during Year (Cubic Yards).
Beggs & Cobb Company, rotary screen process. ¹	Dec. 12, 1917	-	- ²	-	12.44
Beggs & Cobb Company, wooden settling basin.	Aug. 12, 1919	6.0 × 4.0	20	-	304.44
Beggs & Cobb Company, outlet intercepting sump.	July 16, 1919	12.0 × 8.0	5	11.00	55.00
American Hide and Leather Company, Factory D.	Nov. 15, 1910	48.0 × 23.1	6	139.50	837.00
Dorington Leather Company, . . .	Dec. 10, 1910	47.2 × 23.0	5½	106.84	587.62
E. Cummings Leather Company, . . .	Nov. 1, 1910	45.9 × 22.6	2	97.60	195.20
W. P. Fox & Sons,	July 12, 1910	47.8 × 22.6	10	270.40	2,740.00
Thayer & Foss,	Sept. 15, 1910	48.1 × 23.1	4½	209.80	944.10
Van Tassell Leather Company, ³ . . .	May 1, 1911	10.2 × 14.5	-	-	-
Van Tassell Leather Company, . . .	May 1, 1911	43.8 × 19.5	3	102.00	306.00
Van Tassell Leather Company, . . .	Dec. 26, 1919	6.0 × 4.0	-	-	-
American Glue Company,	Oct. 1, 1910	47.1 × 23.0	3	136.36	409.08
J. O. Whitten Company,	1902	35.5 × 24.7	23	58.74	1,351.02
J. O. Whitten Company,	1902	67.2 × 12.0	23	8.50	195.50
Morris Kaplan, ³	Jan. 9, 1911	46.8 × 22.9	-	-	-
Morris Kaplan,	Jan. 9, 1911	4.0 × 4.0	50	1.00	50.00
S. C. Parker & Son, ³	Aug. 1, 1910	48.3 × 23.0	-	-	-
Beggs & Cobb Company, Basin No. 1, ^{3,4} .	Jan. 15, 1910	47.0 × 23.0	-	-	-
Beggs & Cobb Company, Basin No. 2, ^{3,4} .	May 9, 1910	47.0 × 23.0	-	-	-
Beggs & Cobb Company, Basin No. 3, ^{3,4} .	Oct. 19, 1911	51.0 × 25.0	-	-	-
Total,	-	-	-	-	7,987.40

¹ By permission of the Board, dated July 25, 1917, effluent formerly passing through three settling basins has been conducted through "Riensch-Wurl" screens and is allowed to enter the Metropolitan sewer by a special 15-inch branch.

Permission was granted with the provision that all existing connections and settling basins shall be left intact and ready for use if necessary.

² Daily, continuous.

³ Not used 1919.

⁴ Basins filled up temporarily.

NORTH METROPOLITAN SEWERAGE SYSTEM.

Table showing Cities and Towns delivering Sewage to this System; Approximate Miles of Sewers connected; Estimated Populations and Areas now contributing; Total Areas ultimately to contribute, and Present Populations on Such Areas; Ratios of Present Contributing Areas to Ultimate Areas, and Ratios of Populations now contributing to Present Total Populations.

[Populations estimated as of December 31, 1919.]

CITIES AND TOWNS.	Miles of Local Sewers connected.	Separate or Combined.	Number of Connections with Local Sewers.	Estimated Number of Persons Served by Each House Connection. ¹	Estimated Population now contributing Sewage.	Estimated Present Total Population.	Estimated Area now contributing Sewage.	Area ultimately to contribute Sewage.	Ratio of Contributing Population to Present Total Population.	Ratio of Contributing Area to Ultimate Area.
Boston (Deer Island),	0.70	Separate.	—	—	430 ²	430	Sq. Miles.	Sq. Miles.	Per Cent.	Per Cent.
Winthrop,	32.43	Separate.	3,040	5.05	15,350	15,460	1.40	1.61	100.0	87.0
Boston (East Boston),	33.97	Separate.	5,130	13.50	69,260	72,000	1.17	2.18	96.1	53.7
Chelsea,	31.01	Separate and combined.	4,267	11.20	47,700	49,480	1.14	2.24	96.6	50.9
Everett,	48.09	Separate and combined.	5,168	7.20	37,210	42,070	2.00	3.34	88.4	59.9
Malden,	66.89	Separate.	7,201	6.90	49,660	53,650	3.15	5.07	92.6	62.1
Melrose,	39.51	Separate.	3,387	4.60	15,580	18,330	1.89	3.73	85.0	50.7
Boston (Charlestown),	21.69	Separate and combined.	5,457	7.30	39,840	40,000	0.67	1.27	99.6	52.8
Cambridge,	156.49	Separate and combined.	16,905	6.70	113,260	114,120	5.05	6.11	99.2	82.7
Somerville,	101.57	Separate and combined.	16,017	5.85	93,870	95,740	3.50	3.96	98.0	88.4
Medford,	65.66	Separate.	6,296	5.65	35,570	36,480	3.17	8.35	97.5	38.0
Winchester,	32.62	Separate.	2,042	5.30	10,820	11,040	1.62	5.95	98.0	27.1
Woburn,	15.62 ³	Separate.	1,259	5.80	7,300	17,160	1.03	12.71	42.5	8.1
Stoneham,	13.46	Separate.	983	4.70	4,620	7,880	0.70	5.50	58.6	12.7
Arlington,	33.02	Separate.	2,477	5.90	14,610	17,840	2.00	5.20	81.9	38.5
Belmont,	22.30	Separate.	1,382	6.20	9,060 ⁴	9,910	1.36	4.66	91.4	29.2
Wakfield,	14.36	Separate.	835	5.70	4,760	14,030	0.60	7.65	33.9	7.8
Lexington,	6.64	—	96	4.40	4,500	4,500	0.24	5.11	9.3	4.7
Revere,	—	—	—	—	—	31,280	2.13	5.86	83.5	36.3
Reading, ⁵	—	—	—	—	—	8,040	—	9.82	—	—
Totals,	779.65	—	85,705	6.95	595,570	659,530	32.82	100.32	90.3	82.7

¹ Estimated from assessors' statement of the number of houses in each city or town on April 1, 1919, and the population from census of 1915.

² Estimated by Supt. Henry A. Higgins of the institution on Deer Island.

³ Exclusive of Mystic valley sewer and tanneries.

⁴ Including 2 connections with McLean Hospital, having an estimated population of 495.

⁵ Reading not connected.

SOUTH METROPOLITAN SEWERAGE SYSTEM.

Table showing Cities and Towns delivering Sewage to this System; Approximate Miles of Sewers connected; Estimated Populations and Areas now contributing; Total Areas ultimately to contribute, and Present Populations on Such Areas; Ratios of Present Contributing Areas to Ultimate Areas, and Ratios of Populations now contributing to Present Total Populations.

[Populations estimated as of December 31, 1919.]

CITIES AND TOWNS.	Miles of Local Sewers connected.	Separate or Combined.	Number of Connections with Local Sewers.	Estimated Number of Persons served by Each House Connection. ¹	Estimated Population now contributing Sewage.	Estimated Present Total Population.	Estimated Area now contributing Sewage.	Area ultimately to contribute Sewage.	Ratio of Contributing Population to Total Population.	Ratio of Contributing Area to Ultimate Area.
							Sq. Miles.	Sq. Miles.	Per Cent.	Per Cent.
Boston (Back Bay),	26.54	Separate and combined,	1,898	22.10	41,950	42,310	1.15	1.61	99.1	71.4
Boston (Brighton),	63.80	Separate and combined,	4,077	11.20	45,060	46,280	3.22	3.74	98.7	86.1
Brookline,	74.86	Separate and combined,	5,041	7.55	38,060	38,350	3.65	6.81	99.2	53.6
Newton,	130.99	Separate,	7,774	5.60	43,530	46,330	7.97	16.88	94.0	47.2
Waltham,	47.90	Separate,	2,985	6.20	18,510	19,440	2.34	4.04	95.2	57.9
Waltham,	47.46	Separate,	3,952	7.80	30,830	32,570	2.44	13.63	94.6	17.9
Boston (Dorchester),	58.46	Separate and combined,	6,016	14.00	84,220	92,550	2.57	12.59	90.7	52.6
Milton,	18.23	Separate and combined,	1,074	5.00	5,370	9,550	1.00	4.57	89.7	8.0
Boston (Hyde Park),	34.57	Separate,	2,449	7.60	18,610	20,750	1.62	4.57	89.7	35.4
Dedham,	17.40	Separate,	908	5.60	5,080	12,430 ²	0.87	9.40	40.9	9.3
Boston (Roxbury), ³	61.37	Separate and combined,	4,095	9.00	33,970 ⁴	46,900	—	1.23	—	—
Boston (West Roxbury),	84.85	Separate,	6,659	5.50	36,620	49,070	2.76	8.92	79.4	30.9
Quincy, ⁵	—	—	—	—	—	45,820	3.54	12.56	79.9	28.2
Wellesley, ⁵	—	—	—	—	—	7,450	—	9.89	—	—
Totals,	606.43	—	46,928	8.70	407,410	510,100	33.13	110.76	79.9	29.9

¹ Estimated from assessors' statement of the number of houses in each city or town on April 1, 1919, and the population from census of 1915.

² Part of town not included in Metropolitan Sewerage District.

³ At present connected with Boston Main Drainage System.

⁴ Including connection with institutions at Austin Farm, having an estimated population of 2,117.

⁵ Wellesley not yet connected with Metropolitan sewer.

BOTH METROPOLITAN SEWERAGE SYSTEMS.

Table showing Areas delivering Sewage to both Systems; Approximate Miles of Sewers connected; Estimated Population and Areas now contributing; Total Areas ultimately to contribute, and Present Populations on Such Areas; Ratios of Present Contributing Areas to Ultimate Areas, and Ratios of Populations now contributing to Present Total Populations.

[Populations estimated as of December 31, 1919.]

SYSTEM.	Miles of Local Sewers connected.	Separate or Combined.	Number of Connections with Local Sewers.	Estimated Number of Persons served by Each House Connection.	Estimated Population now contributing Sewage.	Estimated Present Total Population.	Estimated Area now contributing Sewage.	Area ultimately to contribute Sewage.	Ratio of Contributing Population to Present Total Population.	Ratio of Contributing Area to Ultimate Area.
North Metropolitan,	779.65	Separate and combined,	85,705	6.95	595,570	659,530	Sq. Miles. 32.82	Sq. Miles. 100.32	Per Cent. 90.3	Per Cent. 32.7
South Metropolitan,	666.43	Separate and combined,	46,928	8.70	407,410	510,100	33.13	110.76	79.9	29.9
Totals, . . .	1,446.08	- -	132,633	7.55	1,002,980	1,169,630	65.95	211.08	85.8	31.2

PUMPING STATIONS.

CAPACITIES AND RESULTS.

The following table shows the comparison of the growth in the amount of sewage handled and the total cost of the operation of the different stations in 1919 with the same items of 1918 and of 1914 when prices had not been affected by the war:—

PUMPING STATION.	SEWAGE PUMPED IN 1919 INCREASED OVER THAT OF —		COST OF OPERATION IN 1919 INCREASED OVER THAT OF —	
	1918.	1914.	1918.	1914.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Deer Island,	6	20	10	63
East Boston,	6	20	4	53
Charlestown,	3	18	10	39
Alewife Brook,	30	40	5	44
Quincy,	35	43	7	54
Ward Street,	19	27	6 ¹	46

¹ Decrease.

Average Daily Volume of Sewage lifted at Each of the Six Principal Metropolitan Sewerage Pumping Stations and at the Quincy (Hough's Neck) Sewage Lifting Station during the Year, as compared with the Corresponding Volumes for the Previous Year.

PUMPING STATION.	AVERAGE DAILY PUMPAGE.			
	Jan. 1, 1919, to Dec. 31, 1919.	Jan. 1, 1918, to Dec. 31, 1918.	Increase during the Year.	
	Gallons.	Gallons.	Gallons.	Per Cent.
Deer Island,	70,300,000	66,500,000	3,800,000	5.7
East Boston,	68,300,000	64,500,000	3,800,000	5.9
Charlestown,	38,400,000	37,300,000	1,100,000	2.9
Alewife Brook,	4,888,000	3,767,000	1,121,000	29.8
Quincy,	5,603,000	4,218,000	1,475,000	35.0
Ward Street (actual gallons pumped), .	33,759,000	28,395,000	5,364,000	18.9
Quincy (Hough's Neck) sewage lifting station.	205,500	173,128	32,372	18.7

NORTH METROPOLITAN SYSTEM.

Deer Island Pumping Station.

At this station are four submerged centrifugal pumps with impeller wheels 8.25 feet in diameter, driven by triple-expansion engines of the Reynolds-Corliss type.

Contract capacity of 1 pump: 100,000,000 gallons, with 19-foot lift.

Contract capacity of 3 pumps: 45,000,000 gallons each, with 19-foot lift.

Average duty for the year: 59,100,000 foot-pounds.

Average quantity raised each day: 70,300,000 gallons.

Force employed: 4 engineers, 1 relief engineer, 4 firemen, 4 oilers, 3 screenmen, 1 relief screenman and 1 laborer.

Coal used: bituminous, costing from \$8.50 to \$8.52 per gross ton.

Table of Approximate Quantities, Lifts and Duties at the Deer Island Pumping Station of the North Metropolitan System.

MONTHS.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1919.						
January,	2,321,700,000	74,900,000	51,100,000	128,800,000	11.61	64,700,000
February,	2,009,900,000	71,800,000	55,500,000	119,100,000	11.20	60,300,000
March,	2,706,900,000	87,300,000	74,000,000	119,800,000	11.83	64,400,000
April,	2,169,900,000	72,300,000	58,000,000	132,700,000	11.56	64,700,000
May,	2,413,000,000	77,800,000	59,800,000	110,800,000	11.62	61,300,000
June,	1,788,700,000	59,600,000	51,700,000	75,300,000	10.67	53,500,000
July,	1,697,700,000	54,800,000	38,500,000	87,100,000	10.90	54,500,000
August,	1,755,400,000	56,600,000	41,600,000	102,100,000	10.91	54,300,000
September,	2,355,000,000	78,500,000	47,100,000	132,400,000	11.48	63,100,000
October,	1,856,200,000	59,900,000	47,300,000	78,000,000	10.81	56,100,000
November,	2,314,200,000	77,100,000	49,800,000	147,100,000	9.99	52,100,000
December,	2,243,100,000	72,400,000	54,900,000	85,200,000	9.03	60,200,000
Total,	25,631,700,000	—	—	—	—	—
Average,	—	70,300,000	52,400,000	109,900,000	10.97	59,100,000

*Average Cost per Million Foot-gallons for Pumping at the Deer Island Station.*Volume (23,631.7 Million Gallons) \times Lift (10.97 Feet) = 281,179.7 Million Foot-gallons.

ITEMS.	Cost.	Cost per Million Foot-gallons.
Labor,	\$21,717 79	\$0.07724
Coal,	25,294 12	0.08996
Oil,	675 84	0.00240
Waste,	95 17	0.00034
Water,	1,333 20	0.00474
Packing,	300 71	0.00107
Miscellaneous supplies and renewals,	1,051 20	0.00374
Totals,	\$50,468 03	\$0.17949
Labor at screens,	\$4,006 31	—

East Boston Pumping Station.

At this station are four submerged centrifugal pumps, with impeller wheels 8.25 feet in diameter, driven by triple-expansion engines of the Reynolds-Corliss type.

Contract capacity of 1 pump: 100,000,000 gallons with 19-foot lift.

Contract capacity of 3 pumps: 45,000,000 gallons each, with 19-foot lift.

Average duty for the year: 71,600,000 foot-pounds.

Average quantity raised each day: 68,300,000 gallons.

Force employed: 4 engineers, 2 relief engineers, 3 firemen, 1 relief fireman, 4 oilers, 3 screenmen, 1 relief screenman, 3 helpers and 1 laborer.

Coal used: bituminous costing from \$7.75 to \$8.70 per gross ton.

Table of Approximate Quantities, Lifts and Duties at the East Boston Pumping Station of the North Metropolitan System.

MONTHS.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1919.						
January,	2,259,700,000	72,900,000	49,100,000	126,800,000	14.68	63,900,000
February,	1,953,900,000	69,800,000	53,500,000	117,100,000	14.88	76,400,000
March,	2,644,900,000	85,300,000	72,000,000	117,800,000	14.49	74,500,000
April,	2,109,900,000	70,300,000	56,000,000	130,700,000	15.07	69,600,000
May,	2,351,000,000	75,800,000	57,800,000	108,800,000	14.76	72,700,000
June,	1,728,700,000	57,600,000	49,700,000	73,300,000	14.66	62,600,000
July,	1,635,700,000	52,800,000	36,500,000	85,100,000	14.66	63,700,000
August,	1,693,400,000	54,600,000	39,600,000	100,100,000	14.82	75,200,000
September,	2,205,000,000	76,500,000	45,100,000	130,400,000	14.69	74,600,000
October,	1,794,200,000	57,900,000	45,300,000	76,000,000	15.35	77,200,000
November,	2,254,200,000	75,100,000	47,800,000	145,100,000	14.22	73,400,000
December,	2,181,100,000	70,400,000	52,900,000	83,200,000	12.19	75,700,000
Total,	24,901,700,000	—	—	—	—	—
Average,	—	68,300,000	50,400,000	107,900,000	14.54	71,600,000

Average Cost per Million Foot-gallons for Pumping at the East Boston Station.

Volume (24,901.7 Million Gallons) \times Lift (14.54 Feet) = 362,070.7 Million Foot-gallons.

ITEMS.	Cost.	Cost per Million Foot-gallons.
Labor,	\$27,065 55	\$0.07475
Coal,	25,798 20	0.07126
Oil,	1,049 76	0.00290
Waste,	101 05	0.00028
Water,	1,780 68	0.00492
Packing,	152 44	0.00042
Miscellaneous supplies and renewals,	3,595 27	0.00993
Totals,	\$59,542 95	\$0.16446
Labor at screens,	\$1,946 67	—

Charlestown Pumping Station.

At this station are three submerged centrifugal pumps, two of them having impeller wheels 7.5 feet in diameter, the other 8.25 feet in diameter. They are driven by triple-expansion engines of the Reynolds-Corliss type.

Contract capacity of 1 pump: 60,000,000 gallons with 8-foot lift.

Contract capacity of 2 pumps: 22,000,000 gallons each, with 11-foot lift.

Average duty for the year: 48,500,000 foot-pounds.

Average quantity raised each day: 38,400,000 gallons.

Force employed: 4 engineers, 1 relief engineer, 4 firemen, 3 oilers, 3 screenmen and 1 relief screenman.

Coal used: bituminous, costing from \$8.25 to \$9.20 per gross ton.

Table of Approximate Quantities, Lifts and Duties at the Charlestown Pumping Station of the North Metropolitan System.

MONTHS.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1919.						
January,	1,338,200,000	43,200,000	30,700,000	69,300,000	7.98	48,600,000
February,	1,114,600,000	39,800,000	31,900,000	68,100,000	8.32	58,500,000
March,	1,417,000,000	45,700,000	34,600,000	65,600,000	8.07	59,700,000
April,	1,117,100,000	37,200,000	30,100,000	63,500,000	7.51	48,000,000
May,	1,256,500,000	40,500,000	30,500,000	63,800,000	7.44	48,200,000
June,	1,011,400,000	33,700,000	29,100,000	44,700,000	7.21	41,800,000
July,	1,115,200,000	36,000,000	26,400,000	61,600,000	7.83	49,700,000
August,	1,102,500,000	35,600,000	27,400,000	58,800,000	7.53	45,000,000
September,	1,184,500,000	39,500,000	25,700,000	69,300,000	7.27	43,700,000
October,	963,300,000	31,100,000	22,700,000	44,800,000	7.89	43,300,000
November,	1,151,400,000	38,400,000	24,400,000	68,500,000	6.44	46,500,000
December,	1,258,200,000	40,600,000	29,600,000	56,900,000	7.03	49,500,000
Total,	14,029,900,000	—	—	—	—	—
Average,	—	38,400,000	28,600,000	61,200,000	7.54	48,500,000

Average Cost per Million Foot-gallons for Pumping at the Charlestown Station.

Volume (14,029.9 Million Gallons) \times Lift (7.54 Feet) = 105,785.4 Million Foot-gallons.

ITEMS.	Cost.	Cost per Million Foot-gallons.
Labor,	\$18,660 57	\$0.17640
Coal,	10,068 20	0.09517
Oil,	301 36	0.00285
Waste,	75 18	0.00071
Water,	631 35	0.00597
Packing,	25 60	0.00024
Miscellaneous supplies and renewals,	961 38	0.00909
Totals,	\$30,723 64	\$0.29043
Labor at screens,	\$3,073 22	—

Alewife Brook Pumping Station.

The plant at this station consists of two 9-inch Andrews commercial centrifugal pumps, direct connected by horizontal shafts to compound marine engines, together with a pump and engine added later. The latter consists of a specially designed engine of the vertical cross-compound type, having between the cylinders a centrifugal pump rotating on a horizontal axis.

Contract capacity of the 2 original pumps: 4,500,000 gallons each, with 13-foot lift.

Contract capacity of new pump: 13,000,000 gallons, with 13-foot lift.

Average duty for the year: 18,300,000 foot-pounds.

Average quantity raised each day: 4,888,000 gallons.

Force employed: 3 engineers, 1 relief engineer, 3 screenmen and 1 relief screenman.

Coal used: bituminous, costing from \$7.78 to \$11.46 per gross ton.

Table of Approximate Quantities, Lifts and Duties at the Alewife Brook Pumping Station of the North Metropolitan System.

MONTHS.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1919.						
January,	160,838,000	5,188,000	4,143,000	8,583,000	13.11	17,600,000
February,	133,749,000	4,777,000	3,669,000	7,462,000	13.08	18,200,000
March,	206,482,000	6,661,000	5,300,000	8,701,000	13.12	21,800,000
April,	174,077,000	5,803,000	4,799,000	8,229,000	13.11	19,700,000
May,	162,056,000	5,228,000	4,201,000	7,226,000	12.84	18,700,000
June,	116,427,000	3,881,000	2,928,000	4,677,000	12.99	17,000,000
July,	107,722,000	3,475,000	2,833,000	6,206,000	12.90	16,700,000
August,	105,593,000	3,406,000	2,833,000	5,494,000	12.97	15,800,000
September,	172,726,000	5,758,000	3,430,000	9,232,000	13.13	21,600,000
October,	114,518,000	3,694,000	3,028,000	4,860,000	13.00	15,000,000
November,	156,079,000	5,203,000	3,862,000	7,462,000	13.08	18,300,000
December,	173,169,000	5,586,000	4,201,000	6,931,000	13.14	19,000,000
Total,	1,783,436,000	—	—	—	—	—
Average,	—	4,888,000	3,769,000	7,089,000	13.04	18,300,000

Average Cost per Million Foot-gallons for Pumping at the Alewife Brook Station.

Volume (1,783.436 Million Gallons) \times Lift (13.04 Feet) = 23,256.01 Million Foot-gallons.

ITEMS.	Cost.	Cost per Million Foot-gallons.
Labor,	\$7,051 00	\$0.30319
Coal,	4,248 66	0.18269
Oil,	329 49	0.01417
Waste,	134 36	0.00578
Water,	299 04	0.01286
Packing,	83 52	0.00359
Miscellaneous supplies and renewals,	366 29	0.01575
Totals,	\$12,512 36	\$0.53803
Labor at screens, oiling and miscellaneous services,	\$3,771 43	—

SOUTH METROPOLITAN SYSTEM.

Ward Street Pumping Station.

At this station are two vertical, triple-expansion pumping engines, of the Allis-Chalmers type, operating reciprocating pumps, the plungers of which are 48 inches in diameter with a 60-inch stroke.

Contract capacity of 2 pumps: 50,000,000 gallons each, with 45-foot lift.

Average duty for the year: 79,459,000 foot-pounds.

Average quantity raised each day: 33,759,000 gallons.

Force employed: 4 engineers, 1 relief engineer, 4 firemen, 5 oilers, 4 assistant engineers, 1 machinist and 1 laborer.

Coal used: bituminous, costing from \$7.59 to \$9.52 per gross ton.

Material intercepted at screens during the year: 1,582.1 cubic yards.

Table of Approximate Quantities, Lifts and Duties at the Ward Street Pumping Station of the South Metropolitan System.

MONTHS.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1919.						
January,	1,074,055,000	34,646,000	27,665,000	48,372,000	40.48	78,350,000
February,	829,106,000	29,610,000	27,341,000	46,892,000	40.69	72,600,000
March,	1,223,136,000	39,455,000	34,162,000	45,122,000	41.46	92,519,000
April,	1,126,616,000	37,554,000	33,995,000	49,120,000	42.77	91,583,000
May,	1,148,405,000	37,045,000	31,886,000	44,782,000	42.14	86,443,000
June,	884,241,000	29,474,000	23,828,000	36,824,000	42.36	73,723,000
July,	854,269,000	27,557,000	22,122,000	42,743,000	42.40	75,316,000
August,	845,944,000	27,290,000	22,664,000	38,080,000	42.23	75,064,000
September,	1,179,787,000	39,326,000	25,498,000	51,217,000	41.62	78,222,000
October,	929,388,000	29,980,000	26,975,000	33,807,000	42.23	67,556,000
November,	1,099,108,000	36,637,000	27,337,000	46,486,000	40.20	76,134,000
December,	1,132,496,000	36,532,000	30,777,000	42,885,000	40.27	85,995,000
Total,	12,326,551,000	—	—	—	—	—
Average,	—	33,759,000	27,854,000	43,861,000	41.57	79,459,000

Records from plunger displacements.

Average Cost per Million Foot-gallons for Pumping at the Ward Street Station.

Volume (12,326.551 Million Gallons) \times Lift (41.57 Feet) = 512,414.73 Million Foot-gallons.

ITEMS.	Cost.	Cost per Million Foot- gallons.
Labor,	\$22,803 10	\$0.04450
Coal,	16,821 64	0.03283
Oil,	487 43	0.00095
Waste,	60 81	0.00012
Water,	1,580 48	0.00308
Packing,	-	-
Miscellaneous supplies and renewals,	5,563 21	0.01086
Totals,	\$47,316 67	\$0.09234
Labor at screens,	\$6,078 88	-

Quincy Pumping Station.

At this station are two compound condensing Deane pumping engines and one Lawrence centrifugal pump driven by a Sturtevant compound condensing engine.

Contract capacity of 3 pumps: Deane, 3,000,000 gallons; Deane, 5,000,000 gallons; Lawrence centrifugal, 10,000,000 gallons.

Average duty for the year: 35,100,000 foot-pounds.

Average quantity raised each day: 5,693,000 gallons.

Force employed: 3 engineers, 1 relief engineer, 3 screenmen and 1 relief screenman.

Coal used: bituminous, costing \$8.35 per gross ton.

Material intercepted at screen during the year: 329 cubic yards.

Table of Approximate Quantities, Lifts and Duties at the Quincy Pumping Station of the South Metropolitan System.

MONTHS.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1919.						
January,	178,806,000	5,768,000	4,541,000	7,984,000	27.00	33,900,000
February,	137,540,000	4,912,000	3,788,000	6,829,000	25.17	31,000,000
March,	218,656,000	7,053,000	4,993,000	11,110,000	31.09	38,200,000
April,	183,192,000	6,106,000	5,288,000	7,610,000	30.32	37,600,000
May,	174,014,000	5,613,000	4,946,000	6,505,000	27.44	35,000,000
June,	145,781,000	4,859,000	4,181,000	6,113,000	23.66	37,100,000
July,	136,742,000	4,411,000	3,719,000	6,280,000	21.60	30,000,000
August,	141,122,000	4,552,000	3,780,000	6,300,000	21.93	33,500,000
September,	233,608,000	7,787,000	4,772,000	11,910,000	27.50	39,400,000
October,	169,251,000	5,460,000	5,087,000	7,250,000	23.98	37,600,000
November,	176,913,000	5,897,000	4,789,000	7,308,000	27.42	34,000,000
December,	182,829,000	5,898,000	4,722,000	7,262,000	29.58	33,800,000
Total,	2,078,454,000	—	—	—	—	—
Average,	—	5,693,000	4,551,000	7,705,000	26.39	35,100,000

Average Cost per Million Foot-gallons for Pumping at the Quincy Station.

Volume (2,078.454 Million Gallons) \times Lift (26.39 Feet) = 54,850.4 Million Foot-gallons.

ITEMS.	Cost.	Cost per Million Foot-gallons.
Labor,	\$6,743 84	\$0.12295
Coal,	4,884 75	0.08906
Oil,	115 80	0.00211
Waste,	53 44	0.00097
Water,	366 91	0.00669
Packing,	74 63	0.00136
Miscellaneous supplies and renewals,	1,139 09	0.02077
Totals,	\$13,378 46	\$0.24391
Labor at screens, oiling and miscellaneous services,	\$3,632 77	—

Nut Island Screen-house.

The plant at this house includes two sets of screens in duplicate actuated by small reversing engines of the Fitchburg type. Two vertical Deane boilers, 80 horse power each, operate the engines, provide heat and light for the house, burn materials intercepted at the screens, and furnish power for the Quincy (Hough's Neck) sewage lifting station.

Average daily quantity of sewage passing screens: 65,100,000 gallons.

Total material intercepted at screens: 1,115.1 cubic yards.

Material intercepted per million gallons of sewage discharged: 1.27 cubic feet.

Force employed: 3 engineers, 1 relief engineer, 3 screenmen and 1 relief screenman.

Coal used: bituminous, costing \$8.60 per gross ton.

Quincy (Hough's Neck) Sewage Lifting Station.

At this station are two 6-inch submerged Lawrence centrifugal pumps with vertical shafts actuated by two Sturtevant direct-current motors.

The labor and electric energy for this station are supplied from the Nut Island screen-house and as used at present it does not materially increase the amount of coal used at the latter station. The effluent is largely ground water.

Contract capacity of 2 pumps: about 1,500,000 gallons each, with 20-foot lift.

Average daily amount pumped: 205,500 gallons.

Average lift: 15.35 feet.

Coal delivered in the Bins of the Sewerage Pumping Stations during the Year.

	GROSS TONS, BITUMINOUS COAL.							Price per Gross Ton.
	Deer Island Pumping Station.	East Boston Pumping Station.	Charlestown Pumping Station.	Alewife Brook Pumping Station.	Ward Street Pumping Station.	Quincy Pumping Station.	Nut Island Screening-house.	
Maritime Coaling Co., . . .	1,455	-	-	-	-	-	-	\$8 50
Maritime Coaling Co., . . .	656	-	-	-	-	-	-	8 52
Maritime Coaling Co., . . .	-	515	-	-	-	-	-	7 75
Maritime Coaling Co., . . .	-	1,793	-	-	-	-	-	8 25
Maritime Coaling Co., . . .	-	385	-	-	-	-	-	8 28
Maritime Coaling Co., . . .	-	300	-	-	-	-	-	8 70
Maritime Coaling Co., . . .	-	-	900	-	-	-	-	8 25
Maritime Coaling Co., . . .	-	-	340	-	-	-	-	9 20
Gorman-Leonard Coal Co., . . .	-	-	-	69	-	-	-	7 78
Frederick A. Potts & Co., . . .	-	-	-	50	-	-	-	7 96
Clitter Coal Co., . . .	-	-	-	49	-	-	-	7 99
Gorman-Leonard Coal Co., . . .	-	-	-	48	-	-	-	8 19
E. Russell Norton, . . .	-	-	-	37	-	-	-	8 30
Gorman-Leonard Coal Co., . . .	-	-	-	53	-	-	-	8 59
Gorman-Leonard Coal Co., . . .	-	-	-	45	-	-	-	8 64
Gorman-Leonard Coal Co., . . .	-	-	-	46	-	-	-	8 71
William A. Jepson Corp., . . .	-	-	-	124	-	-	-	8 80
Locke Coal Co., . . .	-	-	-	14	-	-	-	10 08
Locke Coal Co., . . .	-	-	-	76	-	-	-	11 46
Geo. E. Warren Co., . . .	-	-	-	-	276	-	-	7 60
Geo. E. Warren Co., . . .	-	-	-	-	237	-	-	7 59
Riverside Coal Co., . . .	-	-	-	-	729	-	-	7 62
Geo. E. Warren Co., . . .	-	-	-	-	48	-	-	7 64
Geo. E. Warren Co., . . .	-	-	-	-	538	-	-	7 70
Geo. E. Warren Co., . . .	-	-	-	-	-	351	-	8 35
Maritime Coaling Co., . . .	-	-	-	-	-	-	348	8 60
J. A. Whittemore's Sons Co., . . .	-	-	-	-	376	-	-	9 52
Total bituminous, . . .	2,111	2,993	1,240	611	2,204	351	348	-
Average cost, . . .	\$8 51	\$8 21	\$8 51	\$8 76	\$7 95	\$8 35	\$8 60	-

METROPOLITAN SEWERAGE OUTFALLS.

The Metropolitan Sewerage districts now have outfalls in Boston Harbor at five points, two of which may discharge sewage from the North District and three from the South District. These outfalls are all in good condition.

During the year the sewage of the North District has been discharged wholly through the outlet located near Deer Island light. The other outfall of this system is closed by a cast-iron cover which can be easily removed.

Of the outfalls of the South District, two extend for a distance exceeding one mile from the shore of Nut Island, Quincy, and the third one, called an emergency outlet, extends about 1,500 feet from the same. In the first four months of this year discharge was made jointly through the two regular outfalls. During the balance of the year discharge was made from the easterly line alone. The emergency outfall was not opened during the year except for an occasional flushing.

During the year the average flow through the North Metropolitan District outfall at Deer Island has been 70,300,000 gallons of sewage per 24 hours, with a maximum rate of 153,200,000 gallons during a stormy period in November, 1919. The amount of sewage discharged in the North Metropolitan District averaged 118 gallons per day for each person, taking the estimated population of the District contributing sewage. If the sewers in this District were restricted to the admission of sewage proper only, this per capita amount would be considerably decreased.

In the South Metropolitan District an average of 65,100,000 gallons of sewage has passed daily through the screens at the Nut Island screen-house, and has been discharged from the outfalls into the outer harbor. The maximum rate of discharge per day, which occurred during a heavy storm on September 4, 1919, was 144,500,000 gallons. The discharge of sewage through these outfalls represents the amount of sewage contributed by the South Metropolitan District, which was at the rate of 160 gallons per day per person of the estimated number contributing sewage in the District.

The daily discharge of sewage per capita is considerably larger in the South Metropolitan District than it is in the North Metropolitan

District, because, owing to the large size and unused capacity of the South District High-level Sewer, more storm water is at present admitted to the sewers of this District.

Material intercepted at the Screens.

The material intercepted at the screens at the North Metropolitan Sewerage stations, consisting of rags, paper and other floating materials, has during the year amounted to 1,715.9 cubic yards. This is equivalent to 1.807 cubic feet for each million gallons of sewage pumped at Deer Island.

The material intercepted at the screens at the South Metropolitan Sewerage stations has amounted to 3,026.2 cubic yards, equal to 3.44 cubic feet per million gallons of sewage delivered at the outfall works at Nut Island.

Studies of sewage flows in the Metropolitan sewers and siphons indicate that they are free from deposit.

FREDERICK D. SMITH,

Director and Chief Engineer.

Boston, January 1, 1920.

APPENDIX

APPENDIX No. 1.

CONTRACTS MADE AND PENDING DURING

[NOTE. — The details of contracts made before

1. Number of Contract.	2. WORK.	3. Num- ber of Bids.	AMOUNT OF BID.		6. Contractor.
			4. Next to Lowest.	5. Lowest.	
1 391 ¹	Furnishing water valves: 2 12-inch, 3 16-inch and 2 36-inch screw lift valves.	3	\$8,050 00	\$5,710 00 ²	Chapman Valve Mfg. Co., Indian Orchard, Mass.
2 392 ¹	Furnishing cast-iron frames and covers; about 18,000 pounds.	3	711 00	625 50 ²	Gibby Foundry Co., East Boston.
3 393 ¹	Furnishing 820 tons cast-iron water pipe: 90 tons 12-inch, 400 tons 16-inch and 330 tons 36-inch pipe and 25 tons special castings. (Contract also included 90 tons 16-inch pipe for Metropolitan Sewerage Works).	5	37,555 00 ²	37,475 00	Warren Foundry & Machine Co., Phillipsburg, N. J.
4 394 ¹	Laying 12-inch water pipes in Boston.	9	4,032 50	3,600 00 ²	Vincenzo Grande, Boston.
5 395 ¹	Laying 16-inch water pipes in Arlington.	11	16,450 50	14,035 00 ²	James Barletta, West Roxbury, Mass.
6 396 ¹	Laying 36-inch water pipes in Chelsea.	9	8,059 00	7,075 00 ²	Coleman Brothers, Chelsea, Mass.
7 39-M	Sale and purchase of electric energy to be developed at Sudbury Dam in Southborough.	2	-4	-4	Edison Electric Illuminating Co. of Boston.

¹ Contract completed.² Contract based upon this bid.

APPENDIX NO. 1.

THE YEAR 1919 — WATER WORKS.

1919 have been given in previous reports.]

7. Date of Contract.	8. Date of Completion of Contract.	9. Prices of Principal Items of Contracts.	10. Value of Work done Dec. 31, 1919.	
May 12, 1919	Oct. 15, 1919	For 12-inch valves, \$410 each; for 16-inch valves, \$530 each and for 36-inch valves, \$1,650 each.	\$5,710 00	1
May 2, 1919	July 24, 1919	For castings, 3.475 cents per pound,	655 70	2
June 10, 1919	-3	For 12-inch, 16-inch and 36-inch pipes, \$42.75 per ton of 2,000 pounds and for special castings, \$100 per ton of 2,000 pounds f. o. b. cars at foundry.	38,000 00	3
Aug. 13, 1919	Nov. 22, 1919	For laying 20-inch cast-iron pipe, \$1.45 per lin. ft.; for laying 4-inch cast-iron pipe for blow-offs and connections, \$2 per lin. ft.; for rock excavation (above or below grade of bottom of trench), \$7 per cu. yd.; for earth excavation below grade of bottom of trench, \$2 per cu. yd.; for chambers for 16-inch and smaller valves, \$60 per chamber; for concrete masonry, \$12 per cu. yd.	3,248 93	4
Aug. 14, 1919	Dec. 16, 1919	For laying 16-inch cast-iron pipe, \$1.65 per lin. ft.; for laying 4-inch cast-iron pipe for blow-offs and connections, \$2 per lin. ft.; for rock excavation above and below grade of bottom of trench, \$6 per cu. yd.; for earth excavation below grade of bottom of trench, \$1.50 per cu. yd.; for chambers for 16-inch and smaller valves, \$65 per chamber; for concrete masonry, \$8 per cu. yd.	15,444 02	5
Aug. 14, 1919	Nov. 28, 1919	For laying 36-inch cast-iron pipe, \$3.60 per lin. ft.; for laying 12-inch cast-iron pipe for blow-offs and connections, \$2 per lin. ft.; for rock excavation above grade of bottom of trench, \$8 per cu. yd.; for rock excavation below grade of bottom of trench, \$10 per cu. yd.; for earth excavation below grade of bottom of trench, \$3 per cu. yd.; for chambers for 36-inch valves, \$150 per chamber; for chambers for 16-inch and smaller valves, \$90 per chamber; for concrete masonry, \$15 per cu. yd.	8,755 07	6
Dec. 21, 1914	Jan. 1, 1922	About 5,000,000 kilowatt hours of energy per year at \$6.25 per thousand kilowatt hours.	93,554 45	7

³ Quantity increased as provided for in contract by orders in October and December for about 46 tons 16-inch pipe.

⁴ Contract based upon bid of \$6.25 per thousand kilowatt hours for entire output. Other bid for portion of output.

CONTRACTS MADE AND PENDING DURING

	1. Number of Contract.	2. WORK.	3. Num- ber of Bids.	AMOUNT OF BID.		6. Contractor.
				4. Next to Lowest.	5. Lowest.	
8	51-M	Sale and purchase of electric energy to be developed at Wachusett Dam in Clinton.	1	-	\$5.30 per M kilowatt hours.	New England Power Co. and Edison Electric Illuminating Co. of Boston.
9	62-M ¹	3,000 tons anthracite screenings.	-	-	-	Dexter & Carpenter, Inc., Boston.
10	63-M ¹	6,000 tons bituminous coal, .	-	-	-	E. Russell Norton, Boston.
11	64-M	8,000 tons bituminous coal, .	4 under W. W. Speci- fica- tions. 3 under Deal- ers' Speci- fica- tions.	\$3.25 per gr. ton.	\$3.09 ² per gr. ton.	George E. Warren Co., Boston.
12	65-M ¹	Iron fence for Mystic Reservoir.	5	\$2,197 00	\$2,029 00 ²	Boston Structural Steel Co., Cambridge.

¹ Contract completed.² Contract based upon this bid.

THE YEAR 1919 — WATER WORKS — *Continued.*

7. Date of Con- tract.	8. Date of Completon of Contract.	9. Prices of Principal Items of Contracts.	10. Value of Work done Dec. 31, 1919.	
Jan. 13, 1917	Jan. 1, 1929	About 7,000,000 kilowatt hours of energy per year at \$5.30 per thousand kilowatt hours.	\$39,614 77	8
May 13, 1918	- ⁵	See previous report,	4,594 45	9
May 17, 1918	Mar. 24, 1919	See previous report,	19,696 85	10
May 7, 1919	-	For bituminous coal, \$3.09 per ton of 2,240 pounds f. o. b. at mines.	14,313 09	11
June 11, 1919	Sept. 27, 1919	For making and delivering iron fence complete, \$2,029,	2,029 00	12

⁵ Contract terminated after the delivery of 2,421 gross tons.

CONTRACTS MADE AND PENDING DURING THE YEAR 1919 — WATER WORKS —
Concluded.

Summary of Contracts 1895 to 1919, inclusive.¹

	Value of Work done Dec. 31, 1919.
Distribution Department, 6 contracts,	\$71,813 72
396 contracts completed from 1896 to 1918, inclusive,	17,573,166 71
	\$17,644,980 43
Deduct for work done on 11 Sudbury Reservoir contracts by the city of Boston, .	512,000 00
Total of 402 contracts,	\$17,132,980 43

¹ In this summary contracts charged to maintenance are excluded.

APPENDIX NO. 2.

TABLE NO. 1. — *Monthly Rainfall in Inches at Various Places on the Metropolitan Water Works, 1919.*

PLACE.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
Wachusett Watershed.													
Princeton,	3.16	2.49	5.18	2.43	5.99	1.00	4.22	4.27	6.14	2.34	5.42	1.85	44.49
Jefferson,	3.65	4.49	5.08	2.50	6.21	3.40	6.44	4.25	8.32	2.30	6.28	2.06	54.98
Sterling,	3.17	3.69	5.69	2.70	6.81	1.48	4.64	4.27	6.43	2.58	6.29	2.30	50.05
Boylston,	2.94	3.36	5.13	2.65	5.23	2.17	4.69	3.89	6.23	2.19	6.06	2.14	46.68
Sudbury Dam,	3.47	3.43	4.70	2.82	4.65	2.11	5.70	3.42	4.91	1.95	6.08	2.06	45.30
Framingham,	3.45	3.41	4.67	2.91	4.92	1.99	4.96	3.90	5.36	2.18	6.09	1.94	45.78
Ashland Dam,	3.34	3.12	4.22	2.72	3.79	1.39	4.66	3.68	5.06	2.13	5.11	1.85	41.07
Cordaville,	3.84	3.65	5.55	3.26	5.06	1.94	6.55	3.98	5.80	2.37	6.32	2.07	50.39
Lake Cochituate,	3.56	3.38	4.72	2.68	4.82	1.90	4.94	3.95	5.94	2.19	6.04	1.95	46.07
Chestnut Hill Reservoir,	3.16	3.89	5.04	3.09	4.99	1.51	5.08	4.75	6.96	2.55	5.13	2.00	48.15
Spot Pond,	3.38	3.41	4.44	2.98	5.26	1.48	4.27	5.44	5.49	2.60	6.09	1.65	46.49
Average of all,	3.37	3.48	4.95	2.80	5.25	1.85	5.10	4.16	6.06	2.31	5.90	1.99	47.22
Average, Wachusett watershed,	3.23	3.51	5.27	2.57	6.06	2.01	5.00	4.17	6.78	2.35	6.01	2.09	49.05
Average, Sudbury watershed,	3.52	3.40	4.79	2.93	4.60	1.86	5.47	3.75	5.28	2.16	5.90	1.98	45.64

TABLE NO. 2. — *Rainfall in Inches at Jefferson, Mass., in 1919.*

DAY OF MONTH.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1,	3	-	-	-	3	-	-	-	3	-	3	-
2,	3	-	-	-	0.87	-	-	-	3	0.16	1.49	-
3,	3	-	-	-	-	-	-	-	3	-	-	-
4,	1.84 ²	-	-	-	0.06	-	-	-	3.70	-	3	-
5,	-	-	3	3	0.37	-	-	-	-	3	1.26 ²	-
6,	-	-	0.16	0.18	-	-	3	3	-	0.22	-	0.35 ¹
7,	0.17 ¹	-	-	0.10	-	-	2.23	0.19	0.02	-	-	-
8,	-	-	3	0.15	-	3	-	-	3	-	-	3
9,	-	-	1.00 ²	0.06	-	0.91	-	-	3	3	-	3
10,	-	-	-	-	3	-	0.66	-	3	0.31	-	1.10 ²
11,	-	-	-	3	3	-	-	-	1.87	-	3	-
12,	-	-	-	0.37	3	-	-	-	0.06	-	3	0.10 ²
13,	-	-	-	-	1.36	-	-	3	-	-	0.86	-
14,	-	3	-	-	-	-	-	0.36	-	0.29	-	0.27 ²
15,	-	0.96 ²	-	-	0.02	-	-	-	3	-	-	-
16,	-	-	3	3	-	-	0.33	-	0.27	3	-	0.07 ¹
17,	-	-	3	1.47	0.71	-	-	-	-	0.42	-	-
18,	-	-	1.21 ²	-	-	-	3	3	-	-	-	-
19,	-	-	0.61	-	-	-	1.54	0.38	-	-	-	-
20,	-	-	-	-	3	0.92	-	-	-	-	-	-
21,	-	3	-	-	3	-	3	-	-	0.07	-	-
22,	-	0.84 ¹	-	-	2.73	-	3	0.44	3	-	0.09	-
23,	3	1.01 ¹	-	-	-	-	1.09	-	2.13	-	-	-
24,	1.56	-	-	3	0.08	-	-	3	0.27	-	-	0.09 ¹
25,	-	3	-	0.17	-	-	-	1.66	-	-	3	-
26,	-	1.00	-	-	-	3	0.09	-	-	0.10	3	-
27,	-	-	3	-	0.01	1.57	-	0.11	-	3	2.25	-
28,	-	0.68	3	-	-	-	-	-	-	0.63	-	-
29,	0.08 ¹	-	2.10 ²	-	-	-	-	-	-	-	0.33	-
30,	-	-	-	-	-	-	-	3	-	3	-	0.08 ¹
31,	-	-	-	-	-	-	0.50	1.11	-	0.10	-	-
Totals,	3.65	4.49	5.08	2.50	6.21	3.40	6.44	4.25	8.32	2.30	6.28	2.06

Total for the year, 34.98 inches.

¹ Snow.² Rain and snow.³ Rainfall included in that following.

TABLE No. 3. — *Rainfall in Inches at Framingham, Mass., in 1919.*

DAY OF MONTH.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1,	3	—	0.58	—	3	—	—	0.12	3	—	3	—
2,	3	—	—	0.01 ¹	0.61	—	—	—	3	0.13	1.31	—
3,	3	—	—	—	—	—	—	—	2.31	3	—	—
4,	1.62 ²	0.02	—	0.03	—	—	—	—	—	0.02	3	—
5,	—	—	3	3	0.15	—	—	—	—	3	3	—
6,	—	—	0.11	0.08	—	0.03	0.45	3	—	0.21	1.40	—
7,	—	—	—	0.17	0.01	3	0.03	0.45	—	—	—	0.30 ¹
8,	0.07 ²	—	—	3	—	3	—	0.01	3	—	—	—
9,	—	—	1.30	0.16	—	0.25	—	—	3	3	—	—
10,	—	—	—	0.04	3	—	0.29	—	1.22	0.19	—	0.99
11,	—	—	—	3	3	—	—	—	0.14	0.06	3	—
12,	—	—	—	0.50	2.19	—	—	—	0.40	—	3	—
13,	—	—	—	—	—	—	—	3	—	—	0.46	—
14,	—	3	—	—	—	—	—	0.74	—	3	—	0.43 ²
15,	—	0.98 ²	—	—	—	—	3	—	0.16	0.42	—	—
16,	—	—	3	0.07	—	—	0.49	—	0.13	3	—	—
17,	—	—	3	1.67	0.43	0.07	—	—	—	0.36	—	0.05 ¹
18,	—	—	3	—	—	—	3	3	—	—	—	—
19,	—	—	1.71 ²	—	—	—	1.13	0.04	—	—	—	—
20,	—	—	—	0.03	3	0.03	—	—	—	—	—	—
21,	—	3	—	—	3	—	3	—	0.01	0.04	—	—
22,	3	0.40 ¹	—	—	3	—	3	—	3	—	0.03	—
23,	3	1.17 ²	—	—	1.18	—	1.90	—	0.69	—	—	—
24,	1.73	—	—	0.14	3	—	—	3	0.28	—	—	0.11 ²
25,	—	3	—	—	0.35	—	—	1.58	—	—	3	—
26,	—	0.78	—	—	—	3	0.07	—	—	0.09	3	—
27,	—	—	3	—	—	1.61	—	0.11	—	3	2.31	—
28,	—	0.06	3	0.01	—	—	—	—	—	0.54	—	—
29,	0.03 ¹	—	0.93 ²	—	—	—	—	—	—	—	3	—
30,	—	—	3	—	—	—	—	0.79	3	3	0.58	0.06 ¹
31,	—	—	0.04	—	—	—	0.60	0.06	0.02	0.12	—	—
Totals,	3.45	3.41	4.67	2.91	4.92	1.99	4.96	3.90	5.36	2.18	6.09	1.94

Total for the year, 45.78 inches.

¹ Snow.² Rain and snow.³ Rainfall included in that following.

TABLE NO. 4. — *Rainfall in Inches at Chestnut Hill Reservoir, 1919.*

DATE.	Amount.	Duration.	DATE.	Amount.	Duration.
Jan. 1,30	7.30 A.M. to 11.30 P.M.	May 1,72	7.15 P.M. to 9.30 A.M.
Jan. 2,	1.25 ²	6.00 A.M. to 10.15 P.M.	May 2,16	11.00 P.M. to 4.30 A.M.
Jan. 3,16 ¹	10.15 P.M. to 7.30 A.M.	May 4,03	7.12 P.M. to 7.30 P.M.
Jan. 4,	1.36	9.15 P.M. to 7.45 A.M.	May 5,	1.86	3.20 P.M. to 3.30 A.M.
Jan. 23,09	5.00 A.M. to 3.30 P.M.	May 10,04	4.00 P.M. to 6.00 P.M.
Jan. 24,			May 13,03	3.30 A.M. to 3.45 A.M.
Jan. 29,			May 15,54	6.25 P.M. to 3.15 A.M.
Total,	3.16		May 17,	1.14	12.15 A.M. to 7.30 A.M.
Feb. 4,04	6.20 P.M. to 10.00 P.M.	May 22,07	8.20 P.M. to 10.00 P.M.
Feb. 14,89	5.20 A.M. to 10.00 A.M.	May 24,40	1.15 P.M. to 9.00 P.M.
Feb. 15,23 ¹	10.00 A.M. to 3.30 P.M.	Total,	4.99	
Feb. 21,35	2.50 P.M. to 9.30 A.M.	June 7,03	2.00 A.M. to 2.45 A.M.
Feb. 22,95 ²	3.15 A.M. to 9.30 A.M.	June 9,40	2.00 A.M. to 2.45 A.M.
Feb. 23,46	9.30 A.M. to 2.45 P.M.	June 10,04	2.00 P.M. to 3.30 P.M.
Feb. 25,92	11.00 P.M. to 10.00 A.M.	June 17,07	11.30 A.M. to 12.30 P.M.
Feb. 26,05	12.30 P.M. to 7.30 A.M.	June 20,15	11.30 P.M. to 7.00 A.M.
Feb. 28,			June 27,82	2.00 P.M. to 8.00 P.M.
Mar. 1,			Total,	1.51	
Total,	3.89		July 6,16	2.30 A.M. to 7.00 A.M.
Mar. 1,56	7.30 A.M. to 1.30 P.M.	July 6,10	8.15 P.M. to 5.30 A.M.
Mar. 5,13	5.15 P.M. to 3.30 A.M.	July 7,04	10.15 P.M. to 3.30 A.M.
Mar. 6,	1.25	5.20 A.M. to 6.00 P.M.	July 7,43	7.30 A.M. to 7.10 P.M.
Mar. 11,04	5.00 P.M. to 6.00 P.M.	July 10,59	11.30 P.M. to 2.00 P.M.
Mar. 16,	2.08	5.10 A.M. to 11.20 P.M.	July 15,	1.72	3.45 P.M. to 11.15 A.M.
Mar. 19,10	4.00 A.M. to 4.00 A.M.	July 16,	1.18	4.30 A.M. to 4.15 P.M.
Mar. 23,72	2.10 A.M. to 4.20 P.M.	July 18,15	2.15 P.M. to 7.00 P.M.
Mar. 24,16 ¹	4.20 P.M. to 11.40 A.M.	July 19,71	12.15 A.M. to 7.30 A.M.
Mar. 28,			July 22,		
Mar. 31,			July 23,		
Total,	5.04		July 26,		
Apr. 4,11	5.30 A.M. to 8.00 A.M.	July 31,		
Apr. 5,06	4.30 A.M. to 3.30 A.M.	Total,	5.08	
Apr. 6,30	6.30 P.M. to 11.45 P.M.	Aug. 1,14	12.15 A.M. to 9.00 A.M.
Apr. 7,06	11.45 A.M. to 2.30 P.M.	Aug. 6,53	2.00 P.M. to 10.25 A.M.
Apr. 10,54	11.30 A.M. to 12.00 M.	Aug. 7,	1.86	9.15 P.M. to 5.15 A.M.
Apr. 11,07	4.45 A.M. to 7.30 A.M.	Aug. 13,24	1.50 P.M. to 9.00 A.M.
Apr. 12,	1.68	2.45 P.M. to 9.50 P.M.	Aug. 15,74	3.45 P.M. to 12.15 A.M.
Apr. 16,08	10.15 P.M. to 4.00 A.M.	Aug. 18,20	5.00 A.M. to 1.30 P.M.
Apr. 17,14	2.00 P.M. to 11.15 P.M.	Aug. 25,13	12.45 P.M. to 4.30 P.M.
Apr. 20,05	8.00 P.M. to 3.15 A.M.	Aug. 27,91	12.00 M. to 10.30 A.M.
Apr. 21,			Aug. 30,		
Apr. 24,			Aug. 31,		
Apr. 28,			Total,	4.75	
Apr. 29,					
Total,	3.09				

¹ Snow.² Rain and snow.

TABLE No. 4. — *Rainfall in Inches at Chestnut Hill Reservoir, 1919 —*
Concluded.

DATE.	Amount.	Duration.	DATE.	Amount.	Duration.
Sept. 1, . . .	3.48	5.40 P.M. to	Nov. 1,94	8.15 P.M. to
Sept. 3, . . .		11.30 P.M.	Nov. 2, . . .		2.00 P.M.
Sept. 7,04	4.20 A.M. to 8.30 A.M.	Nov. 3,03	4.30 P.M. to 6.30 P.M.
Sept. 8, . . .	2.09	7.10 P.M. to	Nov. 4, . . .	1.27	3.30 P.M. to
Sept. 12, . . .		6.30 A.M.	Nov. 6, . . .		11.00 A.M.
Sept. 12,05	4.45 P.M. to	Nov. 12,24	9.00 A.M. to
Sept. 13,21	12.15 P.M. to	Nov. 13, . . .		9.00 P.M.
Sept. 16, . . .		9.30 P.M.	Nov. 19,05 ¹	5.15 P.M. to
Sept. 22,92	2.20 P.M. to	Nov. 20, . . .		2.45 A.M.
Sept. 24, . . .		1.30 A.M.	Nov. 22,03	10.20 P.M. to
Sept. 24,16	9.20 P.M. to 10.30 P.M.	Nov. 23, . . .		2.30 A.M.
Sept. 30,01	9.00 P.M. to 9.30 P.M.	Nov. 25, . . .	2.09	6.35 P.M. to
Total, . . .	6.96		Nov. 27, . . .		8.15 A.M.
			Nov. 29,48	11.45 A.M. to
			Nov. 30, . . .		7.30 A.M.
			Total, . . .	5.13	
Oct. 2,15	11.45 P.M. to			
Oct. 3, . . .		7.30 A.M.			
Oct. 4,03	8.30 P.M. to			
Oct. 5, . . .		10.00 A.M.			
Oct. 6,33	8.00 A.M. to 4.45 P.M.			
Oct. 9,24	6.30 P.M. to			
Oct. 10, . . .		6.00 A.M.			
Oct. 11,03	9.15 P.M. to			
Oct. 12, . . .		1.45 A.M.			
Oct. 14,46	1.30 P.M. to	Dec. 6,32 ²	9.20 P.M. to
Oct. 15, . . .		6.20 P.M.	Dec. 7, . . .		2.00 A.M.
Oct. 16,37	8.50 P.M. to	Dec. 7,06	2.05 A.M. to 5.00 P.M.
Oct. 17, . . .		9.30 A.M.	Dec. 8, . . .	1.05	6.10 P.M. to
Oct. 21,10	7.20 P.M. to	Dec. 10, . . .		7.30 A.M.
Oct. 22, . . .		5.30 A.M.	Dec. 12,11	6.50 A.M. to 2.00 P.M.
Oct. 26,09	2.00 P.M. to 5.00 P.M.	Dec. 14,22 ²	3.15 A.M. to 4.00 P.M.
Oct. 27,58	9.30 P.M. to	Dec. 16,07 ¹	11.00 P.M. to
Oct. 28, . . .		9.00 A.M.	Dec. 17, . . .		6.30 A.M.
Oct. 30,17	6.30 P.M. to	Dec. 24,11 ¹	5.00 A.M. to
Oct. 31, . . .		7.30 A.M.	Dec. 25, . . .		1.30 A.M.
Total, . . .	2.55		Dec. 30,06 ¹	9.30 A.M. to 5.15 P.M.
			Total, . . .	2.00	

Total for the year, 48.15 inches.

¹ Snow.² Rain and snow.

TABLE No. 5. — *Rainfall in Inches on the Wachusett Watershed, 1897 to 1919.*

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
1897.		2.86	4.01	2.32	5.06	5.11	8.65	3.47	1.93	0.94	7.62	6.41	51.84
1898.		3.30	2.27	4.43	3.38	3.11	3.01	10.61	3.15	7.21	6.81	3.99	57.52
1899.		5.12	6.75	1.94	1.33	5.51	3.82	3.20	4.11	2.72	1.94	2.03	41.40
1900.		8.69	6.19	2.76	4.34	3.59	3.20	3.18	3.46	2.90	6.44	3.15	52.46
1901.		1.13	5.82	9.64	7.02	1.51	5.66	4.58	3.10	3.70	2.43	9.36	55.70
1902.		4.91	5.27	4.36	2.24	2.51	3.87	3.95	4.26	6.36	0.93	7.20	48.58
1903.		4.42	6.58	3.10	1.24	10.37	3.43	3.88	2.93	4.43	2.36	3.99	49.58
1904.		4.02	7.45	7.45	2.99	3.44	3.84	3.68	5.30	1.78	1.62	2.88	43.06
1905.		6.10	1.72	2.60	0.83	4.83	5.39	3.09	6.90	1.81	2.52	3.79	43.58
1906.		2.59	2.74	3.12	6.58	5.95	5.52	4.34	2.61	3.95	2.25	4.26	49.08
1907.		2.84	1.82	2.65	2.96	3.54	3.03	1.26	9.50	5.08	5.74	4.40	45.74
1908.		3.40	2.77	2.62	5.34	1.29	3.85	6.49	1.04	2.13	1.05	3.03	37.83
1909.		3.52	6.10	5.71	2.65	3.03	4.25	3.59	3.90	1.70	1.68	3.99	44.80
1910.		5.86	5.24	1.09	2.13	4.36	1.52	3.87	2.86	1.40	4.17	2.34	37.85
1911.		2.91	2.43	3.79	1.59	2.37	2.53	5.46	3.04	5.24	4.14	3.01	38.78
1912.		2.57	2.42	4.06	5.76	0.48	2.65	2.89	2.17	2.53	4.02	4.95	40.19
1913.		3.38	2.55	3.90	3.71	0.90	2.37	3.05	4.44	6.02	2.59	2.73	41.22
1914.		3.40	3.38	4.91	3.01	2.00	3.92	4.50	0.15	1.88	2.97	3.89	38.94
1915.		6.31	3.32	1.80	1.67	3.18	8.60	6.90	1.53	3.05	3.12	5.11	44.65
1916.		1.60	5.98	3.65	3.34	6.57	5.66	1.72	4.21	1.42	3.15	2.81	43.43
1917.		3.37	3.05	4.21	3.89	4.47	1.22	4.46	1.20	6.03	1.25	2.31	37.26
1918.		2.97	4.25	2.24	1.07	4.57	2.80	2.82	7.18	1.58	3.08	3.74	39.77
1919.		3.23	3.51	5.27	6.06	2.01	5.00	4.17	6.78	2.35	6.01	2.09	49.05
Totals.	82.99	87.12	93.96	84.09	78.19	84.75	93.79	93.16	85.75	76.81	77.89	91.46	1,031.96
Average (23 years),	3.61	3.79	4.08	3.65	3.40	3.68	4.03	4.14	3.73	3.34	3.39	3.98	44.87

¹ Means of observations at four places, as follows: January, 1897, to December, 1900, Princeton, Jefferson, Sterling and South Clinton; January, 1901, to December, 1916, Princeton, Jefferson, Sterling and Boylston.

TABLE No. 6. — *Rainfall in Inches on the Sudbury Watershed, 1875-1919.*

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
1875,		3.15	3.74	3.23	3.56	6.24	3.57	5.53	3.43	4.85	4.83	0.94	45.49
1876,	2.42	4.21	7.43	4.20	2.76	2.04	9.13	1.72	4.62	2.24	5.76	3.62	49.56
1877,	1.33	0.74	8.36	3.43	3.70	2.43	2.95	3.68	0.32	8.52	5.80	0.87	44.02
1878,	3.22	5.63	4.69	5.79	0.96	3.88	2.97	6.94	1.29	6.42	7.02	6.37	57.93
1879,	5.63	5.97	5.14	4.72	1.58	3.79	3.93	6.51	1.88	0.81	2.68	4.34	41.42
1880,	2.48	3.56	3.31	3.11	1.84	2.14	6.27	4.01	1.60	3.74	1.78	2.83	38.18
1881,	3.57	3.98	5.73	2.00	3.51	5.39	2.35	1.36	2.62	2.95	4.09	3.96	44.17
1882,	5.56	4.65	2.65	1.82	5.07	1.66	1.77	1.67	8.74	2.07	1.15	2.30	39.40
1883,	5.95	4.55	1.78	1.84	4.19	2.40	2.68	0.73	1.52	5.60	1.81	3.55	32.78
1884,	2.81	3.87	1.07	3.60	3.48	3.44	3.67	4.65	0.85	2.48	2.65	5.17	47.14
1885,	5.09	6.54	4.72	4.41	3.47	2.87	1.43	7.18	1.43	5.09	6.09	2.72	43.54
1886,	4.71	3.87	3.61	2.22	3.00	1.47	3.27	4.10	2.90	3.24	4.64	4.97	46.06
1887,	6.36	6.28	4.90	4.27	1.16	2.65	3.76	5.28	1.32	2.83	2.67	3.88	42.70
1888,	5.20	4.78	6.02	2.43	4.82	2.54	1.41	6.22	8.59	4.99	7.22	5.40	57.47
1889,	4.15	3.68	6.02	2.43	2.80	2.80	8.94	4.18	4.60	4.25	6.29	3.14	49.95
1890,	5.37	1.65	2.37	3.41	2.95	2.03	2.46	3.87	6.00	10.51	1.20	5.31	53.00
1891,	2.53	3.51	7.73	2.64	5.21	2.03	3.39	4.73	2.38	3.09	3.68	3.68	49.52
1892,	7.02	5.23	6.48	3.91	2.01	3.77	3.99	4.73	2.84	1.17	5.80	1.13	41.83
1893,	3.14	5.85	4.06	0.83	5.58	2.76	4.23	4.44	2.84	1.17	5.80	1.13	41.83
1894,	2.92	8.20	3.67	3.60	6.61	2.38	2.57	5.41	1.74	4.07	2.20	4.86	48.23
1895,	4.09	3.91	1.43	3.42	4.24	1.15	3.26	2.03	2.63	5.34	3.43	4.81	39.74
1896,	4.06	1.39	2.98	5.25	2.02	2.77	5.04	4.15	2.30	10.68	6.63	3.35	50.62
1897,	2.39	7.18	5.24	1.57	2.57	3.22	2.51	2.40	7.72	3.76	3.02	2.12	43.70
1898,	4.00	2.91	3.66	2.82	4.37	4.46	5.44	3.51	2.94	0.47	6.40	5.21	46.19
1899,	6.83	4.49	2.40	4.66	3.22	2.48	4.09	8.17	2.62	6.71	6.93	3.28	55.88
1900,	4.18	4.91	7.01	1.90	1.45	2.51	3.22	1.43	3.95	2.69	2.18	1.78	37.21
	4.96	9.14	6.35	2.58	4.32	2.99	2.42	2.26	3.36	3.83	5.70	2.74	50.65

1 See note at end of this table.

TABLE No. 6. — *Rainfall in Inches on the Sudbury Watershed,¹ 1875-1919* — Concluded.

YEAR.	January.	Febru- ary.	March.	April.	May.	June.	July.	August.	Septem- ber.	October.	Novem- ber.	Decem- ber.	Totals.
1901,	56.11
1902,	1.82	1.52	6.57	8.60	7.23	1.38	5.71	4.57	3.30	2.82	2.90	9.69	61.11
1903,	2.52	6.18	5.34	4.13	1.86	2.89	2.94	3.40	4.54	4.44	1.45	6.38	46.07
1904,	3.80	3.95	6.63	2.99	0.93	9.25	2.77	3.40	1.75	4.72	1.56	3.14	45.16
1905,	4.87	3.00	2.62	8.87	2.65	2.80	1.96	3.86	5.80	1.64	1.73	2.92	42.82
1906,	5.26	2.20	3.15	2.72	1.31	5.00	5.47	2.70	6.88	1.54	2.07	4.01	42.31
1907,	2.47	2.92	6.32	2.88	5.66	3.91	3.42	3.02	3.30	3.40	2.69	4.49	44.48
1908,	3.28	2.17	1.91	3.41	3.63	3.53	1.86	1.07	8.76	4.17	6.12	4.47	44.38
1909,	3.60	4.56	3.82	1.88	5.51	0.86	3.71	4.57	0.97	2.55	0.98	3.14	36.15
1910,	3.98	5.79	4.26	4.67	2.43	2.81	1.59	2.93	4.74	1.12	3.38	4.05	41.75
1911,	5.39	5.06	0.85	2.75	1.29	4.68	2.03	2.62	2.49	1.86	4.13	2.49	35.64
1912,	2.88	2.77	3.59	2.81	1.01	2.53	3.19	4.94	2.75	3.69	4.62	3.60	38.38
1913,	2.94	2.77	6.46	4.37	4.55	0.46	3.24	3.05	1.76	2.35	3.64	5.13	40.72
1914,	3.17	2.82	5.75	4.25	3.97	1.98	3.60	3.64	3.77	5.53	2.65	3.18	44.31
1915,	3.85	4.07	4.57	5.10	3.08	1.90	3.44	3.82	0.29	1.60	2.53	3.46	37.71
1916,	6.51	3.58	0.05	2.48	1.74	3.65	8.12	5.87	1.10	2.95	2.79	5.09	43.93
1917,	1.53	5.91	4.16	4.19	3.43	4.77	5.17	2.01	1.80	1.40	2.28	3.22	39.96
1918,	3.50	2.68	4.96	2.41	4.93	4.23	1.11	6.40	1.52	5.65	1.31	2.31	41.51
1919,	3.47	3.58	2.50	4.43	1.16	3.65	4.07	1.61	8.60	1.04	2.75	3.68	40.54
1919,	3.52	3.40	4.79	2.93	4.60	1.86	5.47	3.75	5.28	2.16	5.90	1.98	45.64
Totals,	181.54	184.42	194.93	159.53	148.62	138.40	165.60	173.66	153.59	167.86	166.54	169.26	2,003.95
Average (45 years),	4.03	4.10	4.33	3.55	3.30	3.08	3.68	3.86	3.41	3.73	3.70	3.76	44.53

¹ Means of observations at several places, as follows: January, 1875, to March, 1876, inclusive, Lake Cochituate; April and May, 1876, Lake Cochituate, Westborough and Hopkinton; June to November, 1876, inclusive, Lake Cochituate, Southborough, Marlborough, Westborough and Hopkinton; December, 1876, to December, 1882, inclusive, Framingham, Southborough, Marlborough, Westborough and Hopkinton; January, 1883, to December, 1889, inclusive, Framingham and Westborough; January, 1890, to May, 1898, inclusive, Framingham and Ashland Dam; since June, 1898, Framingham, Ashland Dam, Cordaville and Sudbury Dam.

TABLE No. 7. — *Yield of the Wachusett Watershed in Gallons per Day per Square Mile,¹ 1897-1919.*

MONTH.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.
January,	796,000	1,563,000	2,092,000	796,000	519,000	1,676,000	1,265,000	659,000	1,266,000	1,132,000	1,458,000	1,738,000
February,	931,000	1,635,000	1,090,000	4,054,000	356,000	1,401,000	2,133,000	927,000	452,000	1,027,000	692,000	1,736,000
March,	2,760,000	3,088,000	2,776,000	3,722,000	2,718,000	3,992,000	3,423,000	3,008,000	3,004,000	1,860,000	1,697,000	2,192,000
April,	1,632,000	2,027,000	3,378,000	1,580,000	4,986,000	2,159,000	2,238,000	2,984,000	1,617,000	2,109,000	1,436,000	1,269,000
May,	1,163,000	1,390,000	862,000	1,382,000	2,729,000	1,031,000	569,000	1,498,000	445,000	1,533,000	965,000	1,415,000
June,	1,181,000	828,000	561,000	578,000	985,000	410,000	2,131,000	762,000	542,000	1,184,000	773,000	403,000
July,	1,442,000	333,000	354,000	217,000	477,000	292,000	624,000	497,000	365,000	728,000	335,000	220,000
August,	896,000	1,325,000	236,000	197,000	512,000	297,000	474,000	355,000	321,000	591,000	87,000	443,000
September,	380,000	676,000	250,000	127,000	320,000	241,000	375,000	494,000	1,228,000	277,000	810,000	88,000
October,	243,000	1,509,000	245,000	282,000	647,000	950,000	689,000	347,000	367,000	530,000	1,382,000	158,000
November,	1,283,000	2,170,000	430,000	875,000	517,000	635,000	634,000	343,000	442,000	749,000	2,540,000	125,000
December,	2,275,000	2,061,000	359,000	1,570,000	3,234,000	1,848,000	954,000	440,000	1,018,000	794,000	1,961,000	337,000
Average,	1,253,000	1,551,000	1,051,000	1,264,000	1,507,000	1,248,000	1,285,000	1,025,000	926,000	1,043,000	1,180,000	847,000
Average, driest six months,	886,000	1,013,000	312,000	377,000	576,000	471,000	626,000	413,000	541,000	613,000	725,000	238,000

¹ See note at end of this table.

TABLE No. 7. — *Yield of the Wachusett Watershed in Gallons per Day per Square Mile,¹ 1897-1919* — Concluded.

MONTH.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	Mean for 23 Years, 1897-1919.
January,	592,000	1,846,000	773,000	780,000	1,414,000	990,000	2,062,000	1,315,000	686,000	484,000	1,341,000	1,184,000
February,	2,556,000	1,845,000	625,000	927,000	867,000	1,181,000	1,961,000	1,816,000	916,000	2,024,000	794,000	1,389,000
March,	2,129,000	2,640,000	1,339,000	2,831,000	2,263,000	3,137,000	572,000	1,891,000	2,472,000	2,590,000	3,155,000	2,577,000
April,	2,422,000	1,034,000	1,393,000	2,281,000	2,083,000	2,593,000	926,000	3,300,000	1,468,000	1,608,000	1,711,000	2,097,000
May,	1,212,000	608,000	461,000	1,797,000	1,033,000	1,699,000	455,000	1,697,000	1,317,000	673,000	2,204,000	1,223,000
June,	632,000	824,000	351,000	331,000	280,000	317,000	228,000	2,054,000	1,229,000	523,000	462,000	764,000
July,	233,000	62,000	57,000	135,000	19,000	329,000	1,083,000	1,086,000	264,000	280,000	400,000	427,000
August,	193,000	186,000	188,000	125,000	60,000	261,000	1,657,000	284,000	309,000	150,000	262,000	409,000
September,	208,000	145,000	181,000	89,000	219,000	—12,000	158,000	294,000	84,000	603,000	1,093,000	362,000
October,	90,000	68,000	718,000	145,000	678,000	136,000	387,000	140,000	555,000	341,000	495,000	483,000
November,	363,000	354,000	1,035,000	442,000	660,000	211,000	498,000	321,000	313,000	582,000	1,835,000	755,000
December,	537,000	391,000	1,067,000	793,000	955,000	372,000	1,359,000	400,000	339,000	1,056,000	1,292,000	1,112,000
Average,	918,000	828,000	682,000	891,000	879,000	934,000	942,000	1,215,000	834,000	902,000	1,257,000	1,065,000
Average, driest six months,	270,000	201,000	327,000	210,000	318,000	208,000	666,000	432,000	320,000	412,000	752,000	533,000

¹ The area of the watershed used in making up these records included water surfaces amounting to 2.2 per cent of the whole area from 1897 to 1902 inclusive, 2.4 per cent in 1903, 3.6 per cent in 1904, 4.1 per cent in 1905, 5.1 per cent in 1906, 6.0 per cent in 1907, 7.0 per cent in 1908, 1909 and 1910, 6.5 per cent in 1911, 6.8 per cent in 1912, 6.9 per cent in 1913, 7.4 per cent in 1914 and 1915, 7.6 per cent in 1916, 7.4 per cent in 1917, 7.2 per cent in 1918, and 7.5 per cent in 1919.

TABLE No. 8. — *Yield of the Sudbury Watershed in Gallons per Day per Square Mile,¹ 1875-1919.*

MONTH.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.
January,	103,000	643,000	658,000	1,810,000	700,000	1,120,000	415,000	1,241,000	335,000	995,000	1,235,000
February,	1,496,000	1,368,000	949,000	2,465,000	1,711,000	1,787,000	1,546,000	2,403,000	1,033,000	2,842,000	1,354,000
March,	1,604,000	4,435,000	4,814,000	3,507,000	2,330,000	1,374,000	4,004,000	2,839,000	1,611,000	3,785,000	1,572,000
April,	3,049,000	3,292,000	2,394,000	1,628,000	3,116,000	1,169,000	1,546,000	867,000	1,350,000	2,853,000	1,815,000
May,	1,188,000	1,138,000	1,391,000	1,394,000	1,114,000	514,000	965,000	1,292,000	937,000	1,030,000	1,336,000
June,	870,000	222,000	597,000	506,000	413,000	175,000	1,338,000	529,000	300,000	416,000	426,000
July,	321,000	183,000	202,000	128,000	157,000	176,000	276,000	86,000	115,000	224,000	62,000
August,	396,000	405,000	121,000	476,000	395,000	119,000	148,000	55,000	79,000	257,000	240,000
September,	207,000	184,000	60,000	161,000	141,000	80,000	197,000	307,000	91,000	44,000	121,000
October,	646,000	234,000	631,000	516,000	71,000	102,000	188,000	299,000	186,000	83,000	336,000
November,	1,302,000	1,088,000	1,418,000	1,693,000	206,000	205,000	395,000	209,000	205,000	175,000	1,177,000
December,	584,000	453,000	1,290,000	3,177,000	463,000	175,000	775,000	315,000	194,000	925,000	1,174,000
Average,	972,000	1,135,000	1,214,000	1,452,000	804,000	578,000	979,000	862,000	533,000	1,129,000	901,000
Average, driest six months, . .	574,000	384,000	502,000	532,000	230,000	143,000	330,000	211,000	145,000	200,000	391,000

¹ See note at end of this table.

TABLE No. 8. — *Yield of the Sudbury Watershed in Gallons per Day per Square Mile, 1875-1919* — Continued.

MONTH.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.
January,	1,461,000	2,589,000	1,053,000	2,782,000	1,254,000	3,018,000	1,870,000	434,000	693,000	1,034,000	1,084,000
February,	4,801,000	2,829,000	1,950,000	1,196,000	1,529,000	3,486,000	943,000	1,542,000	991,000	541,000	2,676,000
March,	2,059,000	2,868,000	3,233,000	1,338,000	3,643,000	4,453,000	1,955,000	3,245,000	2,238,000	2,410,000	3,835,000
April,	1,947,000	2,620,000	2,645,000	1,410,000	1,875,000	2,397,000	871,000	2,125,000	1,640,000	2,515,000	1,491,000
May,	720,000	1,009,000	1,632,000	880,000	1,366,000	583,000	1,259,000	2,883,000	840,000	636,000	360,000
June,	203,000	413,000	421,000	653,000	568,000	413,000	428,000	440,000	419,000	174,000	399,000
July,	116,000	115,000	117,000	634,000	107,000	149,000	214,000	158,000	161,000	231,000	95,000
August,	94,000	214,000	379,000	1,432,000	132,000	163,000	280,000	181,000	209,000	229,000	57,000
September,	117,000	111,000	1,155,000	823,000	457,000	203,000	229,000	108,000	150,000	89,000	388,000
October,	146,000	190,000	1,999,000	1,230,000	2,272,000	210,000	126,000	222,000	374,000	1,379,000	592,000
November,	673,000	369,000	2,758,000	1,941,000	1,215,000	305,000	697,000	319,000	836,000	2,777,000	659,000
December,	1,020,000	643,000	3,043,000	2,241,000	996,000	544,000	485,000	796,000	716,000	1,782,000	657,000
Average,	1,087,000	1,154,000	1,697,000	1,383,000	1,285,000	1,315,000	781,000	1,037,000	770,000	1,152,000	1,019,000
Average, driest six months, .	223,000	234,000	953,000	944,000	747,000	239,000	327,000	237,000	356,000	460,000	314,000

1 See note at end of this table.

TABLE No. 8. — *Yield of the Sudbury Watershed in Gallons per Day per Square Mile, 1875-1919* — Continued.

MONTH.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.
January,	845,000	1,638,000	2,288,000	794,000	437,000	1,763,000	1,736,000	477,000	1,410,000	1,128,000	1,351,000	1,925,000
February,	1,067,000	3,022,000	1,381,000	3,800,000	300,000	1,674,000	2,279,000	882,000	330,000	1,041,000	624,000	1,536,000
March,	2,565,000	2,604,000	4,205,000	3,654,000	2,755,000	4,199,000	3,454,000	2,999,000	2,497,000	2,409,000	1,658,000	2,257,000
April,	1,515,000	1,829,000	2,521,000	1,350,000	4,204,000	1,885,000	2,261,000	3,294,000	1,643,000	1,949,000	1,607,000	1,117,000
May,	915,000	1,246,000	511,000	1,312,000	2,954,000	743,000	351,000	1,745,000	297,000	1,059,000	888,000	1,046,000
June,	962,000	530,000	66,000	316,000	753,000	303,000	1,987,000	419,000	467,000	707,000	761,000	194,000
July,	658,000	231,000	19,000	—18,000	306,000	66,000	445,000	62,000	177,000	398,000	9,000	—14,000
August,	591,000	1,107,000	—35,000	—34,000	424,000	135,000	307,000	170,000	114,000	180,000	—104,000	102,000
September,	182,000	369,000	94,000	65,000	305,000	178,000	130,000	397,000	1,246,000	19,000	541,000	—82,000
October,	94,000	1,160,000	115,000	186,000	412,000	506,000	492,000	191,000	158,000	301,000	741,000	47,000
November,	909,000	1,986,000	304,000	663,000	474,000	444,000	363,000	289,000	279,000	483,000	1,998,000	71,000
December,	1,584,000	1,799,000	220,000	1,096,000	2,605,000	1,779,000	582,000	269,000	887,000	659,000	2,032,000	136,000
Average,	991,000	1,450,000	973,000	1,082,000	1,342,000	1,140,000	1,190,000	931,000	795,000	860,000	1,010,000	694,000
Average, driest six months, .	564,000	777,000	93,000	194,000	445,000	271,000	388,000	228,000	403,000	341,000	471,000	44,000

1 See note at end of this table.

TABLE No. 8. — *Yield of the Sudbury Watershed in Gallons per Day per Square Mile, 1875-1919* — Concluded.

MONTH.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	Mean for 45 Years, 1875-1919.
January.	302,000	1,490,000	519,000	728,000	1,041,000	908,000	1,629,000	942,000	510,000	273,000	1,306,000	1,157,000
February.	2,286,000	1,849,000	700,000	1,197,000	754,000	1,009,000	1,870,000	1,356,000	755,000	1,809,000	917,000	1,642,000
March.	1,734,000	1,954,000	1,144,000	3,092,000	2,090,000	3,029,000	593,000	1,820,000	2,209,000	2,187,000	2,759,000	2,689,000
April.	1,721,000	667,000	1,426,000	2,235,000	2,232,000	2,353,000	590,000	3,037,000	1,405,000	1,466,000	1,713,000	1,969,000
May.	1,004,000	277,000	318,000	1,447,000	867,000	1,550,000	255,000	1,439,000	1,476,000	639,000	1,290,000	1,069,000
June.	239,000	516,000	213,000	148,000	149,000	5,000	101,000	1,198,000	1,041,000	185,000	112,000	482,000
July.	—121,000	—102,000	—14,000	—77,000	—62,000	107,000	1,045,000	585,000	43,000	96,000	299,000	181,000
August.	—45,000	—73,000	20,000	—29,000	—54,000	156,000	1,168,000	78,000	202,000	—54,000	92,000	233,000
September.	149,000	5,000	76,000	—28,000	88,000	—135,000	38,000	26,000	58,000	637,000	713,000	233,000
October.	—51,000	—51,000	296,000	—14,000	484,000	—59,000	231,000	—5,000	482,000	274,000	279,000	407,000
November.	82,000	176,000	593,000	165,000	480,000	97,000	261,000	110,000	438,000	489,000	1,275,000	734,000
December.	263,000	221,000	908,000	494,000	732,000	250,000	898,000	315,000	380,000	938,000	1,095,000	948,000
Average.	625,000	570,000	514,000	779,000	733,000	772,000	719,000	904,000	750,000	736,000	988,000	975,000
Average, driest six months.	40,000	29,000	151,000	26,000	180,000	29,000	480,000	186,000	267,000	269,000	458,000	377,000

¹ The area of the Sudbury watershed used in these records included water surfaces amounting to 1.9 per cent of the whole area from 1875 to 1878, inclusive, and was subsequently increased by the construction of storage reservoirs, to 3.0 per cent in 1879, 3.4 per cent in 1885, 3.9 per cent in 1891, and 6.5 per cent in 1898. The watershed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.

NOTE. — Since 1897 the reservoirs on the Sudbury watershed have been full of water nearly all the time, while large quantities of water have been received from the Wachusett Reservoir and the recorded yield has been affected by these conditions, especially during dry weather.

TABLE No. 9. — *Wachusett System. — Statistics of Flow of Water, Storage and Rainfall in 1919.*
 [Watershed above dam = 108.84 square miles.]

Month.	GALLONS PER DAY.							Rainfall (Inches).	Rainfall collected (Inches).	Percent- age of Rainfall collected.
	Received from City of Worcester Watershed. ¹	Discharged into Wachusett Aqueduct. ¹	Wasted into River below Dam.	Seepage through the North Dike. ²	STORAGE. ³		Total Yield of Watershed.			
					Gain.	Loss.				
January,	2,248,000	86,064,000	1,729,000	800,000	59,603,000	—	145,948,000	3.23	2.392	74.1
February,	2,939,000	65,578,000	1,861,000	800,000	21,098,000	—	86,396,000	3.51	1.279	36.5
March,	22,966,000	28,357,000	1,725,000	882,000	335,435,000	—	343,433,000	5.27	5.621	106.7
April,	18,323,000	69,803,000	2,580,000	973,000	131,240,000	—	186,273,000	2.57	2.954	115.0
May,	12,435,000	108,697,000	116,348,000	1,000,000	26,251,000	—	239,861,000	6.06	3.931	64.9
June,	—	119,257,000	2,767,000	1,000,000	—	72,724,000	50,300,000	2.01	0.798	39.6
July,	—	101,158,000	1,746,000	977,000	—	60,355,000	43,523,000	5.00	0.713	14.3
August,	—	122,490,000	1,719,000	949,000	—	96,639,000	28,519,000	4.17	0.467	11.2
September,	—	95,370,000	1,720,000	937,000	20,916,000	—	118,943,000	6.78	1.887	27.8
October,	—	107,174,000	1,691,000	924,000	—	55,945,000	53,844,000	2.35	0.884	37.6
November,	5,883,000	71,117,000	1,713,000	926,000	131,890,000	—	199,763,000	6.01	3.168	52.7
December,	7,526,000	129,829,000	40,613,000	958,000	—	23,229,000	140,645,000	2.09	2.305	110.4
Total,	—	—	—	—	—	—	—	49.05	26.399	—
Average for year,	6,049,000	92,336,000	14,927,000	928,000	34,665,000	—	136,807,000	—	—	53.8

¹ Including 176,000 gallons per day drawn from aqueduct for the supply of the Westborough State Hospital.

² Estimated.

³ Aggregate storage in Wachusett Reservoir and in ponds and mill reservoirs.

TABLE No. 10. — *Sudbury System. — Statistics of Flow of Water, Storage and Rainfall in 1919.*
 [Watershed = 75.2 square miles.]

Month.	GALLONS PER DAY.										Rain-fall collected (Inches).	Rain-fall collected (Inches).	Percentage of Rain-fall collected.
	Water received from Wachusett Reservoir. ¹	Water discharged through Sudbury Aqueduct.	Water discharged through Weston Aqueduct.	Water used by Framingham Water Works.	Water diverted from Watershed by Sewers, etc.	Water wasted into River below Lowest Dam.	STORAGE.		Total Yield of Watershed.				
							Gain.	Loss.					
January, .	85,919,000	72,497,000	47,287,000	926,000	1,768,000	65,774,000	—	4,129,000	98,203,000	3.52	2,329	66.1	
February, .	65,411,000	57,361,000	48,614,000	850,000	1,400,000	39,346,000	—	13,225,000	68,936,000	3.40	1,477	43.4	
March, .	28,193,000	43,423,000	50,242,000	833,000	2,129,000	126,350,000	12,727,000	—	207,511,000	4.79	4,916	102.7	
April, .	69,630,000	57,797,000	48,390,000	823,000	2,180,000	79,587,000	9,683,000	—	128,830,000	2.93	2,957	101.0	
May, .	108,526,000	59,848,000	49,110,000	845,000	1,197,000	60,990,000	33,536,000	—	97,000,000	4.60	2,301	50.0	
June, .	119,084,000	76,326,000	43,533,000	1,050,000	915,000	12,760,000	—	7,057,000	8,443,000	1.86	0.193	10.4	
July, .	100,981,000	77,752,000	43,587,000	994,000	732,000	11,826,000	—	11,426,000	22,481,000	5.47	0.533	9.8	
August, .	122,313,000	71,067,000	45,155,000	997,000	652,000	8,329,000	3,055,000	—	6,942,000	3.75	0.164	4.4	
September, .	95,200,000	62,707,000	51,100,000	997,000	983,000	35,037,000	—	2,027,000	53,597,000	5.28	1,232	23.3	
October, .	106,959,000	70,273,000	47,366,000	1,002,000	816,000	14,361,000	—	5,894,000	20,965,000	2.16	0.498	23.1	
November, .	70,913,000	59,820,000	47,430,000	983,000	1,250,000	62,793,000	—	5,446,000	95,917,000	5.90	2,202	37.3	
December, .	129,645,000	76,929,000	48,416,000	1,093,000	1,510,000	95,339,000	—	11,332,000	82,310,000	1.98	1,952	98.6	
Total, .	—	—	—	—	—	—	—	—	—	45.64	20,754	—	
Av. for year, .	92,159,000	65,568,000	47,509,000	950,000	1,292,000	51,163,000	—	11,000	74,312,000	—	—	45.5	

¹ Not including 176,000 gallons per day drawn from the Wachusett Aqueduct for the supply of the Westborough State Hospital, which were not discharged into Sudbury Reservoir.

TABLE No. 11. — *Cochituate System. — Statistics of Flow of Water, Storage and Rainfall in 1919.*
 [Watershed of lake=17.58 square miles.]

MONTH.	GALLONS PER DAY.						Rainfall collected (Inches).	Rainfall collected (Inches).	Percent- age of Rainfall collected.
	Water discharged through Cochituate Aqueduct.	Water di- verted from Watershed by Sewers, etc.	Water wasted at Outlet of Lake.	STORAGE.		Total Yield of Watershed.			
				Gain.	Loss.				
January,	1,039,000	1,610,000	18,464,000	2,713,000	—	23,826,000	3.56	2.42	67.9
February,	10,421,000	1,336,000	—	7,286,000	—	19,043,000	3.38	1.75	51.6
March,	11,913,000	2,387,000	27,278,000	—	691,000	40,887,000	4.72	4.14	87.8
April,	703,000	2,233,000	22,964,000	157,000	—	26,057,000	2.08	2.56	95.5
May,	—	1,842,000	22,593,000	—	229,000	24,206,000	4.82	2.46	51.0
June,	—	990,000	3,150,000	553,000	—	4,693,000	1.90	0.46	24.3
July,	—	787,000	5,071,000	—	152,000	5,706,000	4.94	0.58	11.5
August,	—	700,000	2,819,000	536,000	—	4,055,000	3.95	0.41	10.4
September,	—	1,190,000	18,430,000	—	1,343,000	18,277,000	5.94	1.79	30.2
October,	—	957,000	5,966,000	841,000	—	7,764,000	2.19	0.79	36.0
November,	—	1,667,000	25,343,000	1,030,000	—	28,040,000	6.04	2.75	45.6
December,	—	2,094,000	21,022,000	—	2,681,000	20,435,000	1.95	2.07	106.3
Total,	—	—	—	—	—	—	46.07	22.18	—
Average for year,	1,956,000	1,483,000	14,509,000	620,000	—	18,568,000	—	—	48.1

¹ Not including the watersheds of Dudley and Dug ponds.

TABLE No. 12. — *Elevations of Water Surfaces of Reservoirs above Boston City Base at the Beginning of Each Month.*

DATE.	Chestnut Hill Reservoir. Ordinary High Water = 134.00.	Lake Cochituate. High Water = 144.36.	Farm Pond. High Water = 159.25.	Spot Pond. High Water = 163.00.	Weston Reservoir. High Water = 200.00.	FRAMINGHAM RESERVOIR.			Ashland Reservoir. Flash Boards 225.23.	Sudbury Reservoir. Flash Boards 259.97.	Hopkinton Reservoir. Flash Boards 305.00.	Whitehall Reservoir. Ordinary High Water = 337.91.	Wachusett Reservoir. Ordinary High Water = 395.00.
						No. 1. Flash Boards 169.32.	No. 2. Flash Boards 177.12.	No. 3. Flash Boards 186.50.					
Jan. 1, 1919, .	133.85	142.91	158.12	163.07	199.92	167.87	176.20	185.09	224.50	258.24	304.18	336.90	381.88
Feb. 1, 1919, .	133.82	143.33	158.38	163.38	199.70	167.85	176.19	184.95	224.61	258.25	304.20	336.16	383.40
Mar. 1, 1919, .	133.97	144.22	158.39	163.38	199.63	168.07	176.38	185.03	224.64	257.19	304.36	336.23	383.89
Apr. 1, 1919, .	133.36	144.13	158.68	163.02	199.30	168.07	176.39	185.17	224.64	257.94	304.41	336.59	392.04
May 1, 1919, .	133.41	144.15	158.74	162.99	199.54	167.86	176.20	184.59	224.53	258.45	304.14	337.46	395.10
June 1, 1919, .	133.63	144.12	158.81	163.01	199.40	169.41	177.37	186.12	225.23	260.05	305.01	337.62	395.68
July 1, 1919, .	133.41	144.19	158.42	163.05	199.38	169.40	177.26	185.12	225.20	259.95	304.99	337.31	394.22
Aug. 1, 1919, .	133.64	144.17	158.27	163.13	199.57	169.45	177.29	185.24	225.26	259.11	305.02	337.24	392.82
Sept. 1, 1919, .	134.49	144.24	158.09	163.31	198.13	169.46	177.31	185.22	225.32	259.47	305.07	336.97	390.59
Oct. 1, 1919, .	133.63	144.07	158.23	162.55	199.34	169.42	177.28	184.67	225.23	259.37	305.05	337.11	391.00
Nov. 1, 1919, .	133.74	144.18	158.03	162.65	199.87	169.45	177.29	185.50	225.40	258.75	305.02	337.16	389.63
Dec. 1, 1919, .	133.64	144.31	158.38	162.85	198.12	168.13	176.45	185.91	224.91	258.56	304.68	337.21	392.41
Jan. 1, 1920, .	133.70	143.96	158.40	162.32	200.26	167.85	176.08	186.84	224.42	258.01	304.06	336.65	392.03

TABLE NO. 13. — *Sources from which and Periods during which Water has been drawn for the Supply of the Metropolitan Water District.**From Wachusett Reservoir into the Wachusett Aqueduct.*

MONTH.	Number of Days during which Water was flowing.	ACTUAL TIME.		Million Gallons drawn.
		Hours.	Minutes.	
January,	25	233	45	2,668.0
February,	25	381	10	1,836.2
March,	19	286	7	877.9
April,	23	210	5	2,094.1
May,	25	254	45	3,369.6
June,	25	275	20	3,577.7
July,	26	260	45	3,135.9
August,	26	301	—	3,797.2
September,	25	240	30	2,861.1
October,	26	254	—	3,326.8
November,	21	195	45	2,133.5
December,	26	277	43	4,024.7
Totals,	292	132.12 days.		33,702.7

From Sudbury Reservoir through the Weston Aqueduct to Weston Reservoir.

MONTH.	Number of Days during which Water was flowing.	ACTUAL TIME.		Million Gallons drawn.
		Hours.	Minutes.	
January,	26	362	10	1,465.9
February,	23	341	35	1,361.2
March,	26	397	54	1,555.4
April,	25	365	1	1,451.7
May,	26	363	44	1,522.4
June,	25	309	43	1,306.0
July,	26	327	56	1,351.2
August,	26	346	47	1,399.8
September,	25	364	14	1,533.0
October,	26	372	3	1,470.3
November,	23	344	—	1,422.9
December,	26	519	37	1,500.9
Totals,	303	183.95 days.		17,340.7

TABLE No. 13 — *Concluded.**From Framingham Reservoir No. 3 through the Sudbury Aqueduct to Chestnut Hill Reservoir.*

MONTH.	Number of Days during which Water was flowing.	Actual Time (Hours).	Million Gallons drawn.
January,	31	744	2,247.4
February,	28	672	1,606.1
March,	31	743	1,344.3
April,	30	720	1,733.9
May,	31	732	1,855.3
June,	30	720	2,289.8
July,	31	744	2,410.3
August,	31	740	2,203.1
September,	30	720	1,881.2
October,	31	745	2,181.4
November,	30	720	1,794.6
December,	31	744	2,384.8
Totals,	365	364.36 days.	23,932.2

Water was drawn from Lake Cochituate to Chestnut Hill Reservoir on 65 days. The total quantity drawn was 713,900,000 gallons.

TABLE No. 14. — *Average Daily Quantity of Water flowing through Aqueducts in 1919, by Months.*¹

MONTH.	Wachusett Aqueduct into Sudbury Reservoir (Gallons).	Weston Aqueduct into Metropolitan District (Gallons).	Sudbury Aqueduct into Chestnut Hill Reservoir (Gallons).	Cochituate Aqueduct into Chestnut Hill Reservoir (Gallons).
January,	85,919,000	47,287,000	72,497,000	1,039,000
February,	65,411,000	48,614,000	57,361,000	10,421,000
March,	28,193,000	50,242,000	43,423,000	11,913,000
April,	69,630,000	48,390,000	57,797,000	703,000
May,	108,526,000	49,110,000	59,848,000	—
June,	119,084,000	43,533,000	76,326,000	—
July,	100,981,000	43,587,000	77,752,000	—
August,	122,313,000	45,155,000	71,067,000	—
September,	95,200,000	51,100,000	62,707,000	—
October,	106,959,000	47,366,000	70,273,000	—
November,	70,913,000	47,430,000	59,820,000	—
December,	129,645,000	48,416,000	76,929,000	—
Average,	92,159,000	47,509,000	65,568,000	1,956,000

¹ Not including quantities wasted while cleaning and repairing aqueducts.

TABLE NO. 15. — (Meter Basis.) *Average Daily Consumption of Water by Districts in the Cities and Towns supplied by the Metropolitan Water Works in 1919. (For Consumption of Water in Whole Metropolitan Water District, see Table No. 17.)*

MONTH.	SOUTHERN LOW SERVICE.	NORTHERN LOW SERVICE.	SOUTHERN HIGH SERVICE.	NORTHERN HIGH SERVICE.	SOUTHERN EXTRA HIGH SERVICE.	NORTHERN EXTRA HIGH SERVICE.	Total District supplied (Gallons).	Estimated Population.	Consumption per Inhabitant (Gallons).
	Boston, excluding East Boston and Charlestown (Gallons).	Portions of Charlestown, Somerville, Chelsea, Everett, Malden, Medford, East Boston and Arlington (Gallons).	Quincy, Watertown, and Portions of Boston, Belmont and Milton (Gallons).	Revere, Winthrop, Swampscott, Nahant, Stoneham, Melrose and Portions of Boston, Chelsea, Everett, Malden, Medford and Somerville (Gallons).	Portions of Boston and Milton (Gallons).	Lexington and Portions of Arlington and Belmont (Gallons).			
January,	45,734,100	26,053,500	45,319,600	8,284,900	643,400	824,700	126,860,200	1,254,270	101
February,	43,325,500	24,671,500	43,486,500	8,069,500	635,800	830,100	121,018,900	1,256,410	96
March,	40,687,500	23,333,700	41,188,000	7,979,200	579,200	854,100	114,621,700	1,258,540	91
April,	40,259,000	22,743,400	40,450,200	7,980,700	612,600	810,400	112,856,300	1,260,680	90
May,	40,596,700	23,195,400	41,197,300	8,358,800	686,400	885,400	114,920,000	1,262,810	91
June,	41,999,400	25,584,400	43,729,900	9,924,300	818,000	1,176,400	123,232,400	1,264,950	97
July,	42,118,800	25,810,100	43,710,300	10,181,400	687,000	1,100,700	123,608,300	1,267,080	98
August,	41,611,600	24,573,100	42,249,100	9,527,000	635,900	923,200	119,519,900	1,269,220	94
September,	43,709,900	24,825,300	43,648,400	9,280,400	702,000	878,700	123,044,700	1,271,350	97
October,	41,891,000	24,545,100	43,671,900	9,113,600	714,700	816,200	120,752,500	1,273,490	95
November,	40,942,600	23,475,200	42,013,000	8,866,600	660,000	765,500	116,722,900	1,275,630	92
December,	46,018,300	27,256,300	46,013,500	9,090,300	646,700	769,400	129,794,500	1,277,760	102
For the year,	42,407,800	24,677,900	43,059,400	8,893,500	668,400	886,500	120,593,500	1,267,080	95

In addition to the above quantities the United States Government Reservation on Peddock's Island was supplied with 20,279,000 gallons, equivalent to a daily average rate of 55,600 gallons, and a part of Saugus with 10,466,000 gallons, equivalent to a daily average rate of 28,700 gallons.

TABLE No. 16. — (Meter Basis.) *Average Daily Consumption of Water in Cities and Towns supplied by the Metropolitan Water Works in 1919.*

City or town, . . .	ARLINGTON.		BELMONT.		BOSTON.		CHELSEA.		EVERETT.		LEXINGTON.		MALDEN.	
	17,530.		9,710.		894,140.		48,840.		41,610.		6,020.		53,150.	
	GALLONS.		GALLONS.		GALLONS.		GALLONS.		GALLONS.		GALLONS.		GALLONS.	
MONTH.	Per Capita.		Per Capita.		Per Capita.		Per Capita.		Per Capita.		Per Capita.		Per Capita.	
	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.
January, . . .	1,075,500	62	527,700	55	95,697,500	120	3,332,800	69	3,117,300	76	333,400	56	2,781,900	53
February, . . .	1,074,600	62	554,900	58	90,954,800	114	3,104,900	66	2,964,100	72	349,000	58	2,603,000	49
March, . . .	1,026,300	59	546,100	57	85,455,100	107	2,988,800	62	2,842,800	69	395,200	66	2,593,000	49
April, . . .	1,011,600	58	571,300	59	84,065,900	105	2,906,700	60	2,704,300	65	345,600	58	2,623,400	50
May, . . .	1,079,500	62	589,200	61	85,469,800	107	2,959,700	61	2,670,900	64	374,700	62	2,588,700	49
June, . . .	1,458,500	83	717,200	74	89,596,200	112	3,189,000	65	2,960,500	71	474,800	79	2,945,400	55
July, . . .	1,424,000	81	683,600	70	90,174,400	112	3,239,200	66	2,833,900	68	457,800	76	2,811,500	53
August, . . .	1,105,500	63	516,000	53	88,480,000	110	3,245,600	66	2,743,000	66	409,100	68	2,500,500	49
September, . . .	1,018,800	58	519,300	53	91,894,600	114	3,181,900	65	2,872,500	69	392,900	65	2,697,200	51
October, . . .	944,500	53	481,200	49	89,988,000	111	3,158,200	64	2,832,100	68	389,100	64	2,550,800	48
November, . . .	890,400	50	512,500	52	86,633,100	107	3,031,200	62	2,834,300	68	337,500	61	2,618,000	49
December, . . .	919,300	52	549,700	56	97,338,500	120	3,465,300	70	3,266,900	78	378,200	62	2,786,800	52
For the year, . . .	1,085,700	62	564,000	58	89,652,400	111	3,158,400	65	2,886,700	69	389,200	65	2,682,800	50

TABLE No. 16. — *Average Daily Consumption of Water in Cities and Towns, etc.* — Continued.

City or town,	MONTH.	MEDFORD.		MELROSE.		MILTON.		NAHANT.		QUINCY.		REVERE.	
		35,860.		18,170.		9,450.		1,570.		45,280.		30,640.	
		GALLONS.		GALLONS.		GALLONS.		GALLONS.		GALLONS.		GALLONS.	
		Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.
January,		1,723,800	49	1,036,600	58	339,000	39	84,500	55	4,327,900	97	1,646,800	55
February,		1,645,100	47	983,200	54	375,300	40	86,300	56	4,307,800	96	1,579,100	52
March,		1,619,300	46	1,001,500	55	386,000	41	84,100	54	4,270,500	95	1,486,100	49
April,		1,558,600	44	992,300	55	397,700	42	106,300	68	4,482,400	100	1,526,300	50
May,		1,654,500	46	1,029,500	57	438,300	47	153,500	98	4,516,100	100	1,651,200	54
June,		1,818,700	51	1,183,400	65	436,000	46	310,200	198	4,882,100	108	2,009,100	66
July,		1,783,300	50	1,165,700	64	382,200	40	396,300	252	5,097,800	112	2,221,000	72
August,		1,572,200	44	1,081,800	59	345,100	36	340,500	217	4,701,600	104	2,098,000	68
September,		1,721,600	48	991,300	54	395,400	42	283,800	180	4,577,700	101	1,915,000	62
October,		1,818,200	50	1,134,600	62	414,700	44	188,400	119	4,518,600	99	1,755,900	57
November,		1,654,100	46	1,031,500	56	415,400	44	105,000	66	4,394,700	96	1,642,200	53
December,		1,688,800	46	1,045,100	57	459,100	48	96,400	61	4,505,300	99	1,816,500	58
For the year,		1,688,500	47	1,057,100	58	401,300	42	186,900	119	4,550,100	100	1,780,700	58

TABLE No. 16. — *Average Daily Consumption of Water in Cities and Towns, etc. — Concluded.*

City or town,	MONTH.	SOMERVILLE.		STONEHAM.		SWANSCOTT.		WATERTOWN.		WINTHROP.		METROPOLITAN DISTRICT.	
		94,800.		7,840.		8,160.		19,140.		15,170.		1,257,080.	
		GALLONS.		GALLONS.		GALLONS.		GALLONS.		GALLONS.		GALLONS.	
		Per Capita.		Per Capita.		Per Capita.		Per Capita.		Per Capita.		Per Capita.	
		Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.
January,	.	7,016,000	75	463,400	59	430,400	53	2,196,900	117	698,800	47	126,860,200	101
February,	.	6,529,300	69	459,500	59	416,800	52	2,243,100	119	698,100	47	121,018,900	96
March,	.	6,282,600	67	457,200	59	453,000	56	2,048,800	108	685,300	46	114,621,700	91
April,	.	6,011,100	64	465,500	60	439,200	54	1,964,600	103	683,500	45	112,856,300	90
May,	.	6,170,600	65	535,800	68	506,300	62	1,828,700	96	703,000	47	114,920,000	91
June,	.	6,886,000	73	580,700	74	767,500	94	2,135,900	112	881,200	58	123,232,400	97
July,	.	6,648,500	70	562,700	72	816,300	100	1,887,200	99	1,022,900	67	123,608,300	98
August,	.	6,239,800	66	594,100	76	730,800	89	1,761,000	92	965,300	63	119,519,900	94
September,	.	6,586,300	69	647,800	83	640,400	78	1,883,300	98	824,900	54	123,044,700	97
October,	.	6,448,700	68	732,500	93	564,800	69	2,069,100	107	763,100	50	120,752,500	95
November,	.	6,393,600	67	796,700	101	552,200	67	2,084,200	108	766,300	50	116,732,900	92
December,	.	7,275,400	76	921,800	117	521,700	63	1,957,500	101	892,200	52	129,794,500	102
For the year,	.	6,541,500	69	602,400	77	570,900	70	2,002,900	105	792,000	52	120,593,500	95

TABLE No. 17. — *Consumption of Water in the Metropolitan Water District, as constituted in the Year 1919, and a Small Section of the Town of Saugus, 1893-1919.*

[Gallons per Day.]

MONTH.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.
January,	75,209,000	67,506,000	68,925,000	82,946,000	85,366,000	83,880,000	96,442,000	100,055,000	111,275,000
February,	71,900,000	68,944,000	80,375,000	87,021,000	83,967,000	87,475,000	103,454,000	98,945,000	117,497,000
March,	67,638,000	62,710,000	69,543,000	86,111,000	82,751,000	85,468,000	90,200,000	97,753,000	105,509,000
April,	62,309,000	57,715,000	62,909,000	77,529,000	79,914,000	76,374,000	86,491,000	89,497,000	93,317,000
May,	61,025,000	60,676,000	65,194,000	73,402,000	76,772,000	76,677,000	89,448,000	87,780,000	95,567,000
June,	63,374,000	68,329,000	69,905,000	77,639,000	77,952,000	83,463,000	97,601,000	98,581,000	103,420,000
July,	69,343,000	73,642,000	69,667,000	80,000,000	85,525,000	88,228,000	96,821,000	107,786,000	106,905,000
August,	66,983,000	67,995,000	72,233,000	78,537,000	84,103,000	87,558,000	92,072,000	102,717,000	102,815,000
September,	64,654,000	67,137,000	73,724,000	74,100,000	84,296,000	83,296,000	91,478,000	103,612,000	102,103,000
October,	63,770,000	62,735,000	67,023,000	71,762,000	79,551,000	81,770,000	89,580,000	98,358,000	103,389,000
November,	61,204,000	62,231,000	64,881,000	71,933,000	72,762,000	73,177,000	86,719,000	93,648,000	101,324,000
December,	66,700,000	65,103,000	70,443,000	79,449,000	76,594,000	86,355,000	85,840,000	97,844,000	113,268,000
Average,	66,165,000	65,382,000	69,499,000	78,360,000	80,793,000	83,651,000	92,111,000	98,059,000	104,045,000
Population,	724,180	744,720	765,430	787,880	810,340	832,790	855,250	877,700	892,740
Per capita,	91.4	87.8	90.8	99.5	99.7	100.4	107.7	111.7	117.2

See note at end of this table.

TABLE No. 17. — *Consumption of Water, etc.* — Continued.

[Gallons per Day.]

Month.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.
January,	118,435,000	125,176,000	137,771,000	130,878,000	126,093,000	137,730,000	132,376,000	133,275,000	127,568,000
February,	117,268,000	122,728,000	143,222,000	140,595,000	130,706,000	150,822,000	146,199,000	130,763,000	131,093,000
March,	108,461,000	111,977,000	123,334,000	120,879,000	123,570,000	134,202,000	128,884,000	126,842,000	117,078,000
April,	103,153,000	107,179,000	108,688,000	111,898,000	118,428,000	121,556,000	128,926,000	125,335,000	112,775,000
May,	106,692,000	111,589,000	111,715,000	115,804,000	122,404,000	123,502,000	131,040,000	123,305,000	112,073,000
June,	110,002,000	105,590,000	111,209,000	117,441,000	121,882,000	125,623,000	139,813,000	125,179,000	114,082,000
July,	108,340,000	107,562,000	113,581,000	124,769,000	118,726,000	128,779,000	138,232,000	126,765,000	122,743,000
August,	107,045,000	103,570,000	112,836,000	121,158,000	120,591,000	131,098,000	128,073,000	121,781,000	118,373,000
September,	107,782,000	106,772,000	114,188,000	120,103,000	121,685,000	124,751,000	129,972,000	118,043,000	112,434,000
October,	106,560,000	103,602,000	108,290,000	118,301,000	116,561,000	124,051,000	124,189,000	115,939,000	112,332,000
November,	105,175,000	103,477,000	108,054,000	116,693,000	113,746,000	119,627,000	117,119,000	111,664,000	107,528,000
December,	125,434,000	114,721,000	125,119,000	122,696,000	130,995,000	122,407,000	124,468,000	115,733,000	121,994,000
Average,	110,345,000	110,277,000	118,114,000	121,671,000	122,065,000	128,561,000	130,712,000	122,851,000	117,458,000
Population,	907,780	922,820	937,860	955,920	981,720	1,007,520	1,025,890	1,051,420	1,077,090
Per capita,	121.6	119.5	125.9	127.3	124.4	127.6	127.4	116.8	109.1

See note at end of this table.

TABLE No. 17. — *Consumption of Water, etc. — Concluded.*

[Gallons per day.]

MONTH.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.
January,	123,281,000	137,277,000	113,489,000	117,387,000	109,089,000	110,202,000	115,416,000	146,582,000	130,592,000
February,	124,359,000	141,440,000	120,713,000	127,083,000	108,351,000	112,383,000	120,840,000	156,628,000	124,701,000
March,	116,669,000	122,804,000	107,871,000	110,106,000	102,241,000	109,944,000	109,088,000	140,078,000	116,152,000
April,	111,656,000	113,308,000	104,086,000	103,609,000	98,085,000	100,326,000	102,817,000	125,975,000	114,284,000
May,	118,095,000	114,548,000	104,311,000	105,821,000	98,940,000	103,940,000	102,883,000	126,139,000	115,403,000
June,	114,145,000	118,793,000	108,193,000	114,165,000	104,252,000	103,349,000	106,043,000	128,152,000	123,757,000
July,	123,052,000	120,261,000	112,084,000	106,233,000	101,074,000	106,392,000	113,344,000	127,289,000	124,166,000
August,	111,091,000	112,968,000	106,660,000	105,786,000	101,331,000	110,090,000	114,870,000	128,642,000	119,613,000
September,	108,726,000	112,352,000	105,449,000	109,873,000	108,043,000	108,691,000	109,467,000	125,352,000	123,748,000
October,	106,873,000	110,220,000	103,756,000	105,241,000	103,622,000	108,008,000	107,104,000	121,798,000	122,186,000
November,	105,373,000	109,289,000	101,441,000	101,228,000	101,474,000	103,835,000	103,892,000	119,242,000	119,978,000
December,	104,592,000	110,114,000	102,480,000	108,741,000	103,074,000	106,777,000	120,326,000	122,502,000	132,150,000
Average,	113,951,000	118,546,000	107,466,000	109,489,000	103,227,000	106,994,000	110,475,000	130,551,000	122,227,000
Population,	1,103,290	1,129,500	1,155,710	1,181,920	1,208,160	1,231,460	1,260,760	1,287,050	1,313,350
Per capita,	103.3	105.0	93.0	92.6	85.4	86.7	87.6	101.4	93.1

This table includes the water consumed in the cities and towns enumerated in Table No. 16, together with the water consumed in Newton, which is included in the Metropolitan Water District but has not been supplied from the Metropolitan Works, and a small section of the town of Saugus.

From 1893 to 1903, inclusive, consumption based on pumpage. Since 1903, portion of supply delivered by gravity and measured by meters.

TABLE No. 18. — *Chemical Examinations of Water from the Wachusett Reservoir, Clinton.*

[Parts per 100,000.]

Date of Collection.	APPEARANCE.			Odor.		RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	Hardness.
	Turbidity.	Sediment.	Color.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	ALBUMINOID.				
									Total.	Dissolved.	Suspended.		
Jan. 7	V. slight.	None.	.15	V. faintly vegetable.	Faintly vegetable.	3.10	1.00	.0014	.0124	—	.0014	.28	1.1
Jan. 21	None.	V. slight.	.11	V. faintly vegetable.	Faintly vegetable.	3.75	1.40	.0020	.0120	.0106	.0014	.28	1.1
Feb. 11	None.	V. slight.	.10	V. faintly vegetable.	Faintly vegetable.	3.00	1.10	.0010	.0114	.0086	.0028	.28	1.1
Feb. 18	V. slight.	V. slight.	.10	V. faintly vegetable.	Faintly vegetable.	3.55	1.00	.0016	.0104	.0094	.0010	.28	1.0
Mar. 4	None.	V. slight.	.11	V. faintly vegetable.	Faintly vegetable.	3.80	1.65	.0016	.0102	.0092	.0010	.26	1.1
Mar. 18	None.	V. slight.	.12	V. faintly vegetable.	V. faintly vegetable.	3.65	1.35	.0008	.0086	.0080	.0006	.32	1.1
Apr. 8	None.	V. slight.	.10	V. faintly vegetable.	V. faintly vegetable.	3.00	1.20	.0014	.0144	.0128	.0016	.28	1.1
Apr. 22	V. slight.	V. slight.	.10	V. faintly vegetable.	Faintly vegetable.	2.80	1.00	.0012	.0124	.0116	.0008	.30	1.0
May 6	V. slight.	V. slight.	.12	V. faintly vegetable.	Faintly vegetable.	3.15	1.10	.0026	.0100	.0082	.0018	.30	1.1
May 27	None.	V. slight.	—	V. faintly vegetable.	Faintly vegetable.	3.15	1.00	.0038	.0094	.0086	.0008	.28	1.0
June 3	V. slight.	None.	.20	Faintly vegetable.	Faintly vegetable.	3.00	1.00	.0022	.0144	.0124	.0020	.30	1.0
June 17	V. slight.	V. slight.	.20	V. faintly vegetable.	Faintly vegetable.	3.35	1.10	.0042	.0140	.0118	.0022	.26	1.4
July 8	None.	V. slight.	.22	V. faintly vegetable.	Faintly vegetable.	3.80	1.05	.0042	.0140	.0118	.0022	.26	1.4
July 22	None.	V. slight.	.15	V. faintly vegetable.	Faintly vegetable.	3.60	1.15	.0026	.0164	.0138	.0026	.24	1.1
Aug. 5	None.	V. slight.	.20	V. faintly vegetable.	Faintly vegetable.	4.00	1.00	.0014	.0144	.0084	.0060	.28	1.6
Sept. 9	V. slight.	V. slight.	.10	V. faintly vegetable.	V. faintly vegetable.	2.95	1.00	.0022	.0123	.0118	.0008	.31	1.6
Sept. 23	None.	V. slight.	.20	V. faintly vegetable.	Faintly vegetable.	3.40	1.25	.0026	.0144	.0108	.0036	.29	0.8
Oct. 7	None.	V. slight.	.13	V. faintly vegetable.	Faintly vegetable.	3.05	1.25	.0006	.0114	.0106	.0008	.30	1.0
Oct. 21	None.	V. slight.	.19	V. faintly vegetable.	Faintly vegetable.	3.80	1.45	.0020	.0140	.0122	.0018	.30	1.6
Nov. 4	None.	V. slight.	.16	None.	V. faintly vegetable.	3.20	1.00	.0024	.0146	.0140	.0006	.26	0.6
Nov. 25	None.	V. slight.	.18	V. faintly vegetable.	V. faintly vegetable.	3.65	1.50	.0030	.0092	.0090	.0002	.30	1.0
Dec. 16	V. slight.	V. slight.	.18	V. faintly vegetable.	Faintly vegetable.	3.20	1.55	.0022	.0084	.0072	.0012	.30	0.5
Av.14	3.36	1.19	.0020	.0120	.0098	.0016	.28	1.1

TABLE No. 19. — *Chemical Examinations of Water from the Sudbury Reservoir.*
[Parts per 100,000.]

Date of Collection.	APPEARANCE.			Odor.		RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	Hardness.
	Turbidity.	Sediment.	COLOR.					Platinum Standard.	Free.	ALBUMINOID.			
				Total.	Loss on Ignition.	Total.	Dissolved.			Suspended.			
Jan. 6	V. slight.	V. slight.	.18	V. faintly vegetable.	V. faintly vegetable.	3.35	1.00	.0018	.0122	.0104	.0018	.32	1.3
Feb. 3	None.	V. slight.	.20	V. faintly vegetable.	Faintly vegetable.	3.90	1.20	.0022	.0132	.0124	.0008	.35	1.4
Mar. 3	V. slight.	V. slight.	.16	V. faintly vegetable.	V. faintly vegetable.	3.40	1.30	.0018	.0112	.0100	.0012	.30	1.3
Apr. 14	V. slight.	V. slight.	.20	V. faintly vegetable.	V. faintly vegetable.	4.40	1.50	.0014	.0162	.0124	.0038	.34	1.6
May 5	V. slight.	V. slight.	.20	V. faintly vegetable and grassy.	Faintly vegetable and grassy.	4.00	1.75	.0020	.0154	.0132	.0022	.32	1.4
June 3	V. slight.	V. slight.	.20	Faintly vegetable.	Distinctly vegetable.	4.20	1.55	.0054	.0140	.0118	.0022	.34	1.3
July 9	V. slight.	V. slight.	.21	V. faintly vegetable.	Faintly vegetable.	4.00	1.75	.0014	.0182	.0128	.0054	.34	1.8
Aug. 4	V. slight.	V. slight.	.16	V. faintly vegetable and marshy.	Faintly vegetable and marshy.	4.25	1.75	.0008	.0180	.0158	.0022	.30	1.6
Sept. 3	V. slight.	V. slight.	.11	V. faintly vegetable.	V. faintly vegetable.	3.00	1.20	.0020	.0174	.0132	.0042	.32	1.3
Oct. 6	V. slight.	V. slight.	.19	V. faintly vegetable.	Faintly vegetable.	3.55	1.25	.0026	.0130	.0120	.0010	.36	1.4
Nov. 5	V. slight.	V. slight.	.15	V. faintly vegetable.	V. faintly vegetable.	3.70	1.50	.0018	.0124	.0120	.0004	.30	0.8
Dec. 9	V. slight.	V. slight.	.22	V. faintly vegetable.	V. faintly vegetable.	4.05	1.35	.0024	.0116	.0098	.0018	.31	1.3
Av.18	3.81	1.42	.0021	.0144	.0121	.0022	.32	1.4

TABLE No. 20. — *Chemical Examinations of Water from Spot Pond, Stoneham.*
[Parts per 100,000.]

Date of Collection.	APPEARANCE.		ODOR.		RESIDUE ON EVAPORATION.				AMMONIA.			Chlorine.	Hardness.
	Turbidity.	Sediment.			COLOR.	Platinum Standard.	Free.	ALBUMINOID.					
			Total.	Loss on Ignition.				Total.	Dissolved.	Suspended.			
Jan. 20	None.	V. slight.	.15	Cold. <									

TABLE No. 21. — *Chemical Examinations of Water from Lake Cochituate.*
[Parts per 100,000.]

Date of Collection.	APPEARANCE.			Odor.		RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	Hardness.
	Turbidity.	Sediment.	COLOR. Platinum. Standard.			Total.	Loss on Ignition.	Free.	ALBUMINOID.				
									Total.	Dissolved.	Suspended.		
Jan. 6	Slight.	V. slight.	.23	Faintly vegetable and earthy.	Cold. <								

TABLE No. 22. — *Chemical Examinations of Water from a Tap at the State House, Boston.*
[Parts per 100,000.]

Date of Collection.	APPEARANCE.			Odor.		RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	Hardness.
	Turbidity.	Sediment.	Color.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	ALBUMINOID.				
									Total.	Dissolved.	Suspended.		
Jan. 3	V. slight.	V. slight.	.25	V. faintly vegetable.	V. faintly vegetable.	3.55	1.00	.0020	.0148	.0106	.0042	.34	1.4
Feb. 5	V. slight.	V. slight.	.26	V. faintly vegetable.	Faintly vegetable.	4.30	1.60	.0008	.0130	.0106	.0024	.40	1.4
Feb. 28	V. slight.	V. slight.	.23	V. faintly vegetable.	V. faintly vegetable.	4.95	1.90	.0012	.0124	.0108	.0016	.42	1.6
Apr. 9	V. slight.	V. slight.	.17	V. faintly vegetable.	Faintly vegetable.	4.30	1.30	.0012	.0148	.0128	.0020	.42	1.6
May 13	V. slight.	Slight.	.20	V. faintly vegetable.	V. faintly vegetable.	4.10	1.30	.0006	.0140	.0122	.0018	.32	1.6
May 26	V. slight.	Slight.	.25	V. faintly vegetable.	Faintly vegetable.	4.75	1.20	.0008	.0120	.0108	.0012	.36	1.6
June 5	V. slight.	V. slight.	.20	V. faintly vegetable.	Faintly vegetable.	4.65	1.30	.0010	.0136	.0110	.0026	.36	1.4
July 9	V. slight.	V. slight.	.23	V. faintly vegetable.	Faintly vegetable.	5.50	1.80	.0002	.0158	.0124	.0034	.34	2.0
Aug. 14	V. slight.	V. slight.	.15	V. faintly vegetable.	Faintly vegetable.	3.65	-	.0008	.0114	.0084	.0030	.36	1.7
Sept. 4	V. slight.	V. slight.	.15	V. faintly vegetable.	Faintly vegetable.	3.75	1.25	.0006	.0124	.0108	.0016	.33	1.3
Nov. 6	V. slight.	V. slight.	.16	V. faintly vegetable.	V. faintly vegetable.	3.80	1.55	.0006	.0118	.0102	.0016	.34	1.0
Dec. 8	V. slight.	V. slight.	.19	V. faintly vegetable.	V. faintly vegetable.	4.10	1.35	.0020	.0102	.0090	.0012	.33	1.7
Av.20	4.28	1.41	.0010	.0130	.0108	.0022	.36	1.5

TABLE No. 23. — *Averages of Chemical Examinations of Water from Various Parts of the Metropolitan Water Works in 1919.*
[Parts per 100,000.]

LOCALITY.	Samples collected.	Color.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	Hardness.
			Total.	Loss on Ignition.	Free.	ALBUMINOID.				
						Total.	Dissolved.	Suspended.		
Quinepoxet River, Holden, ¹	Semi-monthly,	48	4.22	1.71	.0024	.0178	.0142	.0030	.30	0.9
Stillwater River, Sterling, ¹	Semi-monthly,	.42	3.82	1.58	.0019	.0151	.0130	.0022	.23	1.1
Wachusett Reservoir, West Boylston, ²	Semi-monthly,	.33	4.04	1.43	.0021	.0154	.0128	.0026	.27	1.1
Wachusett Reservoir, Clinton, surface, ³	Semi-monthly,	.14	3.36	1.19	.0020	.0120	.0098	.0016	.28	1.1
Wachusett Reservoir, Clinton, bottom, ³	Semi-monthly,	.16	3.59	1.35	.0023	.0107	.0096	.0012	.28	1.1
Marlborough (Walker's Brook),	Monthly,	.53	19.95	5.38	.0573	.0285	.0233	.0052	2.72	7.1
Marlborough Brook filter beds, effluent, ⁴	Monthly,	.11	15.05	—	.0025	.0097	—	—	2.36	5.9
Wachusett Aqueduct, Southborough,	Monthly,	.20	4.21	1.49	.0018	.0127	.0108	.0018	.29	1.3
Sudbury Reservoir, surface,	Monthly,	.18	3.81	1.42	.0021	.0144	.0121	.0022	.32	1.4
Sudbury Reservoir, bottom,	Monthly,	.19	4.22	1.37	.0034	.0127	.0191	.0019	.33	1.4
Frammingham Reservoir No. 3, inlet, ⁴	Monthly,	.16	3.87	1.44	.0023	.0135	.0112	.0022	.32	1.4
Frammingham Reservoir No. 3, near dam, ⁴	Monthly,	.18	4.02	1.43	.0031	.0156	.0124	.0032	.35	1.3
Hopkinton Reservoir, surface, ⁴	Monthly,	.99	5.51	2.26	.0045	.0261	.0234	.0027	.43	1.4
Hopkinton Reservoir, inlet, ⁵	Monthly,	.61	4.48	1.91	.0039	.0199	.0185	.0020	.39	1.3
Hopkinton Reservoir, bottom, ⁵	Monthly,	.39	4.68	1.93	.0042	.0189	.0161	.0028	.39	1.3
Ashland Reservoir, inlet, ⁴	Monthly,	1.27	5.96	2.83	.0036	.0305	.0269	.0048	.36	1.3
Ashland Reservoir, surface,	Monthly,	.56	4.56	1.98	.0038	.0224	.0214	.0018	.35	1.3
Ashland Reservoir, bottom,	Monthly,	.55	4.81	1.92	.0042	.0214	.0182	.0032	.35	1.3
Frammingham Reservoir No. 2, inlet, ⁴	Monthly,	.77	5.89	2.23	.0070	.0279	.0229	.0050	.64	1.6
Frammingham Reservoir No. 2, near dam, ⁴	Monthly,	.83	6.05	2.38	.0066	.0249	.0242	.0025	.57	1.5
Lake Cochituate, surface,	Monthly,	.20	6.62	2.06	.0020	.0266	.0200	.0065	.69	2.7
Lake Cochituate, bottom, ⁶	Monthly,	.68	7.81	2.47	.0564	.0262	.0209	.0064	.67	3.1
Weston Reservoir,	Monthly,	.17	4.21	1.49	.0017	.0133	.0114	.0021	.33	1.3
Terminal chamber, Sudbury Aqueduct, ⁷	Monthly,	.18	4.01	1.37	.0022	.0120	.0110	.0027	.35	1.5
Spot Pond, ⁴	Monthly,	.69	3.80	1.29	.0018	.0145	.0122	.0023	.35	1.4
Tap in Revere,	Monthly,	.69	3.50	1.23	.0006	.0129	.0114	.0018	.34	1.4
Tap at State House, ⁴	Monthly,	.20	4.28	1.41	.0010	.0130	.0108	.0022	.36	1.5
Tap in Quincy,	Monthly,	.16	3.94	1.26	.0007	.0111	.0097	.0014	.36	1.5

⁶ Averages of 9 samples.⁷ Averages of 7 samples.⁴ Averages of 11 samples.⁵ Averages of 10 samples.¹ Averages of 20 samples.² Averages of 18 samples.³ Averages of 22 samples.

TABLE NO. 24. — *Chemical Examinations of Water from a Faucet in Boston, 1892-1919.*

[Parts per 100,000.]

YEAR.	COLOR.	RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	Oxygen consumed.	Hardness.
	Platinum Standard.	Total.	Loss on Ignition.	Free.	ALBUMINOID.					
					Total.	Dissolved.	Suspended.			
1892,37	4.70	1.67	.0007	.0168	.0138	.0030	.41	-	1.9
1893,53	4.54	1.84	.0010	.0174	.0147	.0027	.38	.60	1.8
1894,58	4.64	1.83	.0006	.0169	.0150	.0019	.41	.63	1.7
1895,59	4.90	2.02	.0006	.0197	.0175	.0022	.40	.69	0.7
1896,45	4.29	1.67	.0005	.0165	.0142	.0023	.37	.56	1.4
1897,55	4.82	1.84	.0009	.0193	.0177	.0016	.40	.64	1.6
1898,40	4.19	1.60	.0008	.0152	.0136	.0016	.29	.44	1.4
1899,28	3.70	1.30	.0006	.0136	.0122	.0014	.24	.35	1.1
1900,29	3.80	1.20	.0012	.0157	.0139	.0018	.25	.38	1.3
1901,29	4.43	1.64	.0013	.0158	.0142	.0016	.30	.42	1.7
1902,30	3.93	1.56	.0016	.0139	.0119	.0020	.29	.40	1.3
1903,29	3.98	1.50	.0013	.0125	.0110	.0015	.30	.39	1.5
1904,23	3.93	1.59	.0023	.0139	.0121	.0018	.34	.37	1.5
1905,24	3.86	1.59	.0020	.0145	.0124	.0021	.35	.35	1.4
1906,24	3.86	1.39	.0018	.0159	.0134	.0025	.34	.36	1.3
1907,22	3.83	1.40	.0013	.0129	.0109	.0020	.33	.32	1.3
1908,19	3.50	1.35	.0011	.0115	.0092	.0024	.33	.26	1.2
1909,18	3.46	1.43	.0011	.0128	.0103	.0025	.28	.25	1.3
1910,14	3.05	1.24	.0013	.0118	.0102	.0016	.28	.22	1.1
1911,25	4.18	1.66	.0015	.0156	.0128	.0029	.38	.33	1.4
1912,17	3.86	1.23	.0018	.0154	.0119	.0034	.36	.29	1.7
1913,13	3.96	1.15	.0014	.0150	.0120	.0026	.35	.26	1.5
1914,14	4.12	1.19	.0014	.0138	.0116	.0022	.39	.25	1.4
1915,16	3.73	1.04	.0015	.0157	.0134	.0023	.38	.25	1.4
1916,18	4.53	1.85	.0013	.0133	.0107	.0026	.36	-	1.4
1917,15	4.45	1.68	.0015	.0142	.0124	.0018	.33	-	1.3
1918,18	3.89	1.45	.0019	.0154	.0128	.0026	.29	-	1.4
1919,20	4.28	1.41	.0010	.0130	.0108	.0022	.36	-	1.5

TABLE No. 25. — *Microscopic Organisms in Water from Various Parts of the Metropolitan Water Works, 1898-1919.*

[Standard units per cubic centimeter; averages from weekly or biweekly observations.]

YEAR.	WACHUSETT RESERVOIR.		SUDBURY RESERVOIR.		LAKE COCHITUATE.		FRAMINGHAM RESERVOIR No. 3.		FRAMINGHAM RESERVOIR No. 2.		ASHLAND RESERVOIR.		HOPKINTON RESERVOIR.		WHITEHALL RESERVOIR.	
	Surface.	Bottom.	Surface.	Bottom.	Surface.	Bottom.	Surface.	Mid-depth.	Surface.	Surface.	Surface.	Surface.	Surface.	Surface.	Surface.	Surface.
1898,	-	-	354	149	830	696	390	245	263	944	690					
1899,	-	-	470	252	905	644	440	218	357	715	393					
1900,	-	-	498	361	1,758	1,071	645	365	390	980	437					
1901,	-	-	337	225	992	702	336	149	244	450	705					
1902,	-	-	590	402	1,071	730	627	204	550	588	198					
1903,	-	-	549	388	931	795	459	169	323	231	327					
1904,	-	-	517	376	663	542	475	171	153	106	375					
1905,	769	592	644	502	1,255	503	535	158	289	240	147					
1906,	446	272	953	714	1,407	1,143	692	226	431	475	1,279					
1907,	425	212	513	419	1,123	1,200	413	205	378	336	961					
1908,	731	466	850	885	1,559	1,241	932	725	699	516	708					
1909,	2,151	1,937	2,474	2,513	1,142	1,198	2,372	610	603	294	445					
1910,	480	328	464	556	928	1,033	455	436	426	387	154					
1911,	649	368	990	988	1,942	2,216	1,140	378	592	457	397					
1912,	585	368	939	882	4,682	7,873	888	241	665	516	390					
1913,	449	270	553	541	4,964	7,322	560	253	414	298	494					
1914,	753	309	735	692	2,036	4,189	532	-	327	325	89					
1915,	5.9	356	1,005	828	1,900	3,213	701	-	450	284	625					
1916,	922	550	930	992	2,708	1,949	837	-	425	347	148					
1917,	296	240	638	589	1,670	2,216	663	-	-	-	-					
1918,	229	132	475	332	3,492	2,800	455	-	-	-	-					
1919,	380	352	482	527	3,673	2,878	406	-	-	-	-					

See note at end of this table.

TABLE No. 25. — *Microscopic Organisms in Water, etc.* — Concluded.

[Standard units per cubic centimeter; averages from weekly or biweekly observations.]

YEAR.	WESTON RESERVOIR.		SPOT POND.		CHESTNUT HILL RESERVOIR.				TAPS.			
	Surface.		Surface.		SUBURBY AQUEDUCT.	COCHITUATE AQUEDUCT.	EFFLUENT DATE-HOUSE.	No. 2.	Southern Low Service.	Southern High Service.	Northern Low Service.	Northern High Service.
1898,	485	.	304	544	.	304	230	—	—	—
1899,	1,129	.	359	992	.	329	192	201	—	—
1900,	573	.	568	1,139	.	897	468	452	—	—
1901,	628	.	344	697	.	413	243	280	—	—
1902,	581	.	563	937	.	525	367	451	—	—
1903,	650	.	450	860	.	435	285	398	—	—
1904,	465	.	405	838	.	472	303	470	274	189
1905,	609	.	551	904	.	554	528	671	363	388
1906,	783	671	.	631	1,042	.	721	550	583	326	422
1907,	443	590	.	349	909	.	419	312	427	205	422
1908,	979	741	.	783	1,073	.	689	666	695	443	481
1909,	2,399	1,079	.	1,999	632	.	1,899	1,913	1,959	1,313	677
1910,	625	622	.	457	—	.	465	447	421	221	374
1911,	934	748	.	700	1,382	.	954	778	735	349	461
1912,	1,117	716	.	855	3,887	.	919	1,035	967	412	462
1913,	565	607	.	535	2,622	.	850	531	410	237	356
1914,	757	648	.	492	—	.	540	603	549	249	412
1915,	725	656	.	643	—	.	601	597	631	419	631
1916,	857	811	.	842	—	.	1,041	872	858	409	530
1917,	570	446	.	598	638	.	717	569	534	352	294
1918,	415	347	.	417	2,766	.	521	390	485	251	217
1919,	481	456	.	419	4,747	.	515	417	446	197	331

NOTE. — A large growth of *Asterionella* originated in the Wachusett Reservoir in 1909, causing the large number of organisms in the water of Sudbury Reservoir and Framingham Reservoir No. 3, Weston and Chestnut Hill reservoirs, Spot Pond and in the water drawn from taps.

TABLE NO. 26. — *Number of Bacteria per Cubic Centimeter in Water from Various Parts of the Metropolitan Water Works, 1898-1919.*

[Averages of weekly determinations.]

YEAR.	CHESTNUT HILL RESERVOIR.			SOUTHERN SERVICE TAPS.	
	Sudbury Aqueduct Terminal Chamber.	Cochituate Aqueduct.	Effluent Gate-house No. 2.	Low Service, 180 Boylston Street.	High Service, 1 Ashburton Place.
1898,	207	145	111	96	-
1899,	224	104	217	117	123
1900,	248	113	256	188	181
1901,	225	149	169	162	168
1902,	203	168	121	164	246
1903,	76	120	96	126	243
1904,	347	172	220	176	355
1905,	495	396	489	231	442
1906,	231	145	246	154	261
1907,	147	246	118	130	176
1908,	162	138	137	136	148
1909,	193	229	119	150	195
1910,	216	-	180	178	213
1911,	205	204	151	175	197
1912,	429	450	227	249	259
1913,	123	243	157	119	140
1914,	288	-	252	174	220
1915,	163	-	128	117	134
1916,	128	-	85	102	105
1917,	178	112	119	119	141
1918,	1,163	168	705	317	544
1919,	92	85	100	70	84

TABLE No. 27. — *Colors of Water from Various Parts of the Metropolitan Water Works in 1919. (Averages of Weekly Determinations.)*
 [Platinum Standard.]

MONTH.	WACHUSETT RESERVOIR.				SUDBURY RESERVOIR.				FRAM- INGHAM RESER- VOIR No. 3.	LAKE COCHITU- ATE.			CHESTNUT HILL RESERVOIR.			SPOT POND.	FELS RESER- VOIR.	NORTHERN SERVICE.		SOUTHERN SERVICE.			
	Surface.	Mid-depth.	Bottom.	Worcester Street Bridge.	Quinapoxet River.	Stillwater River.	Surface.	Mid-depth.		Bottom.	End of Open Channel.	Surface.	Mid-depth.	Bottom.	Inlet (Sudbury Aqueduct).			Inlet (Cochituate Aqueduct).	Effluent Gate-house No. 2.	Mid-depth.	Effluent Gate-house.	Tap at Glenwood Yard, Medford (Low Serv- ice).	Tap at Fire Station, Hancock Street, Ply- mout (High Service).
January, . . .	10	10	10	28	38	34	15	15	15	15	16	19	19	15	15	14	8	8	8	14	8	14	14
February, . . .	11	10	11	30	29	23	15	15	15	13	15	16	19	15	15	14	8	8	6	14	8	14	14
March, . . .	12	12	13	35	36	32	14	14	14	54 ¹	18	18	20	15	15	14	8	8	8	13	8	14	14
April, . . .	11	11	12	30	34	31	15	15	15	15	17	18	19	15	15	13	5	5	8	13	8	14	14
May, . . .	11	12	11	36	44	42	14	14	15	15	16	18	19	15	15	13	5	5	8	14	8	14	14
June, . . .	12	12	11	25	36	36	15	15	15	12	15	15	15	15	15	13	5	5	8	13	8	14	14
July, . . .	12	13	12	18	48	38	14	14	16	13	15	16	79	14	14	13	5	5	8	14	8	14	14
August, . . .	12	12	12	16	32	21	13	13	13	13	12	16	79	14	14	13	7	7	9	14	7	14	14
September, . . .	11	10	11	19	55	41	12	12	12	16	13	15	116	16	16	12	7	7	10	10	10	10	10
October, . . .	11	11	11	16	53	40	13	13	13	13	14	14	106	13	13	12	7	8	12	12	12	12	12
November, . . .	11	11	12	16	52	42	13	13	14	16	14	14	60	13	13	12	7	7	13	13	7	12	12
December, . . .	11	11	11	21	33	29	15	16	15	13	16	17	17	15	15	14	6	6	7	13	6	13	14
Averages, . . .	11	11	11	24	41	33	14	14	14	18	15	16	46	15	15	13	7	7	13	13	7	13	13

¹ No flow in Wachusett Aqueduct.

TABLE No. 28. — *Temperatures of Water from Various Parts of the Metropolitan Water Works in 1919. (Averages of Weekly Determinations.)*

[The temperatures are taken at the same places and times as the samples for microscopical examination; the depth at place of observation is from high-water mark.]
[Degrees Fahrenheit.]

MONTH.	WACHUSETT ¹ RESERVOIR (DEPTH AT PLACE OF OBSERVATION 107 FEET).			SUDBURY ¹ RESERVOIR (DEPTH AT PLACE OF OBSERVATION 54.5 FEET).			WACHU- SETT AQUE- DUCT.			FRAMINGHAM ¹ RESERVOIR No. 3 (DEPTH AT PLACE OF OBSERVATION 20.5 FEET).			LAKE COCHITUATE ¹ (DEPTH AT PLACE OF OBSERVATION 62.0 FEET).			CHEST- NUT HILL RESER- VOIR.			SPOT POND ¹ (DEPTH AT PLACE OF OBSERVATION 28.0 FEET).			NORTHERN SERVICE.		SOUTHERN SERVICE.					
	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth.	Bottom.	End of Open Channel.	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth.	Bottom.	Tap at Glenwood Park, Medford (Low Service).	Tap at Fire Station, Hancock Street, Fy- erett (High Service).	Tap at 180 Boylston Street, Boston (Low Service).	Tap at 1 Ashburton Place, Boston (High Service).	Surface.	Mid-depth.	Bottom.	Tap at Fire Station, Hancock Street, Fy- erett (High Service).	Tap at 180 Boylston Street, Boston (Low Service).	Surface.	Mid-depth.	Bottom.	
January, . . .	34.2	34.0	35.1	35.9	37.0	38.0	34.5	36.5	36.4	36.9	36.7	37.0	37.5	36.3	36.2	37.7	39.2	37.6	38.1	38.6	37.6	37.7	39.2	37.6	38.1	38.6	37.6	38.1	38.6
February, . . .	33.4	-	34.0	36.4	37.5	39.5	34.5	35.4	35.9	35.5	38.5	38.4	38.6	35.9	37.9	39.3	38.9	38.3	38.4	38.6	38.3	38.9	39.2	38.4	38.4	38.6	38.3	38.4	38.6
March, . . .	36.0	36.2	36.9	38.6	39.8	39.8	39.0	38.9	38.0	40.3	39.9	39.4	39.6	40.6	39.5	40.5	41.4	40.8	41.2	41.9	40.8	40.8	41.4	40.8	41.2	41.9	40.8	41.2	41.9
April, . . .	42.6	44.5	41.3	46.6	45.0	46.5	42.0	47.2	48.2	46.0	45.7	44.6	42.9	46.6	45.5	44.8	46.5	46.5	47.6	48.3	47.6	46.5	46.5	46.5	47.6	48.3	47.6	48.3	47.6
May, . . .	52.0	51.8	47.0	56.8	54.8	54.0	52.0	57.4	57.6	56.3	56.8	48.4	46.0	56.5	55.9	53.0	55.0	55.9	56.5	57.3	56.5	55.0	55.0	56.5	57.3	57.3	56.5	57.3	57.3
June, . . .	66.6	58.0	50.5	69.0	67.8	60.8	60.3	69.3	66.6	65.9	69.2	50.9	47.3	67.3	67.7	67.3	67.8	66.8	67.2	67.5	67.2	67.8	67.8	67.2	67.5	67.5	67.2	67.5	67.5
July, . . .	72.0	59.3	51.3	55.1	69.2	63.5	59.0	73.1	73.2	71.4	72.2	48.7	47.3	73.2	74.0	73.5	71.8	73.0	74.0	73.2	73.0	73.0	72.0	72.0	73.2	73.2	73.0	73.2	73.2
August, . . .	69.3	62.0	54.8	70.9	67.5	67.3	59.5	70.6	70.6	69.2	70.4	50.4	47.3	71.4	71.8	72.1	70.8	73.0	74.0	73.2	73.0	73.0	72.0	72.0	73.2	73.2	73.0	73.2	73.2
September, . . .	65.4	62.8	53.5	67.1	65.5	65.0	60.5	68.0	65.5	65.4	64.9	51.3	46.7	66.7	67.0	66.6	66.3	67.2	67.2	67.2	67.2	67.2	67.2	67.2	67.2	67.2	67.2	67.2	67.2
October, . . .	61.1	58.9	59.5	60.3	61.5	59.7	58.0	60.8	61.0	60.4	57.4	53.0	47.4	58.8	38.9	60.3	57.9	60.5	60.0	60.2	60.8	60.0	60.5	60.0	60.2	60.8	60.8	60.8	60.8
November, . . .	49.3	48.0	50.8	47.3	49.8	49.5	48.5	49.5	47.2	46.0	47.4	46.5	47.4	48.8	46.6	48.8	44.8	50.0	49.1	49.6	48.5	49.1	50.0	48.5	49.1	49.6	49.1	49.6	49.6
December, . . .	37.0	35.5	39.3	35.5	35.3	37.5	34.0	36.2	34.7	36.6	38.0	33.5	39.2	37.8	36.8	37.9	44.2	42.0	40.0	40.5	42.0	44.2	42.0	40.0	40.0	40.5	40.5	40.5	40.5
Averages, . . .	51.6	50.1	46.2	51.6	52.6	51.6	48.5	53.0	52.9	52.5	53.1	45.7	43.8	53.2	51.7	53.3	54.3	54.0	54.3	54.3	54.0	54.3	54.0	54.3	54.3	54.3	54.3	54.7	54.7

¹ Surface temperatures are averages of weekly determinations. Mid-depth and bottom temperatures are averages of biweekly determinations.

TABLE NO. 29. — *Temperatures of the Air at Three Stations on the Metropolitan Water Works in 1919.*

[Degrees Fahrenheit.]

MONTH.	CHESTNUT HILL RESERVOIR.			FRAMINGHAM.			CLINTON.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
January,	59	—7	27.5	56	—	30.8	56	—3	30.1
February,	51	3	27.3	48	9	30.8	— ¹	— ¹	— ¹
March,	67	2	36.5	66	13	40.2	66	12	39.4
April,	68	12	43.5	72	18	46.8	70	17	45.0
May,	89	30	56.0	91	36	59.8	89	37	57.2
June,	100	35	65.8	99	44	69.0	96	43	67.0
July,	99	41	70.0	99	49	73.9	95	51	72.2
August,	88	42	64.8	89	46	67.8	85	49	65.8
September,	89	31	60.5	89	40	63.7	83	37	61.5
October,	79	22	51.7	80	28	54.6	80	26	52.8
November,	66	14	38.4	66	21	41.5	67	20	40.9
December,	56	—14	23.7	57	—8	27.0	66	—10	26.5
Averages for the year,	—	—	47.1	—	—	50.5	—	—	—

¹ Thermometer out of order.

TABLE No. 30. — *Length of Metropolitan Water Works Main Lines and Connections and Number of Valves set in Same, Dec. 31, 1919.*

[Pipes are of cast iron unless otherwise noted.]

	DIAMETER OF PIPES IN INCHES.														Total.	
	60	48	42	40	36	30	24	20	16	14	12	10	8	6		4
Total length owned and operated Dec. 31, 1918 (feet).	43,802 ¹	211,092	9,810	6,989	61,787	49,771 ²	85,496	85,719	68,367	26	26,563	3,829	1,878	994	33	656,156
Gate valves in same,	5	56	1	2	55	44	61	56	83	1	110	20	18	23	1	536
Air valves in same,	51	125	5	3	44	21	43	51	35	—	10	1	—	—	—	389
Length laid or relaid during 1919 (feet),	—	—	7	10	1,882	56	10	—	5,748	—	2,098	—	—	—	—	9,811
Gate valves in same,	—	—	—	1	5	1	—	—	—	—	2	—	—	—	—	9
Air valves in same,	—	—	—	2	3	1	—	—	2	—	1	—	—	—	—	9
Length abandoned during 1919 (feet),	—	—	7	112	43	52	—	—	46	—	—	—	—	—	—	260
Gate valves in same,	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1
Air valves in same,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Length owned and operated Dec. 31, 1919 (feet).	43,802 ¹	211,092	9,810	6,887	63,626	49,775 ²	85,506	85,719	74,069	26	28,661	3,829	1,878	994	33	665,707 ³
Gate valves in same,	5	56	1	3	60	45	61	56	82	1	112	20	18	23	1	544
Air valves in same,	51	125	5	5	47	22	43	51	37	—	11	1	—	—	—	398

¹ Includes 2,035 feet of 76-inch concrete-lined pressure tunnel; 363 feet of 76-inch mortar-lined and concrete-covered steel pipe; 21 feet of 76-inch cast-iron pipe and 85 feet of 60-inch concrete-covered steel pipe.

² Includes 15,512 feet of 30-inch mortar-lined and covered wrought-iron pipe.

³ 126.08 miles.

TABLE No. 31. — *Length of Metropolitan Water Works Hydrant, Blow off and Drain Pipes, Dec. 31, 1919.*

[All pipes are of cast iron.]

	DIAMETER OF PIPES IN INCHES.								Total.
	24	20	16	12	10	8	6	4	
Total length in use Dec. 31, 1918 (feet),	352	292	3,121	6,861	176	513	3,566	1,472	16,353
Valves in same,	—	—	30	108	2	9	85	43	277
Length laid or relaid in 1919 (feet),	—	—	—	21	—	—	—	54	75
Valves in same,	—	—	—	1	—	—	—	3	4
Length abandoned in 1919 (feet),	—	—	—	—	—	—	—	29	29
Valves in same,	—	—	—	—	—	—	—	1	1
Total length in use Dec. 31, 1919 (feet),	352	292	3,121	6,882	176	513	3,566	1,497	16,399 ¹
Valves in same,	—	—	30	109	2	9	85	45	280

¹ 3.11 miles.

TABLE No. 32. — *Length of Metropolitan Water Works Main Lines and Connections and Water Pipes, Four Inches in Diameter and Larger, in the Several Cities and Towns supplied by the Metropolitan Water Works, Dec. 31, 1919.*

BY WHOM OWNED.	INCHES.													TOTALS.					
	60	48	42	40	36	30	24	20	18	16	14	12	10	8	7	6	4	Feet.	Miles.
Metropolitan Water Works,	43,802	211,092	9,810	6,887	63,626	49,775	85,506	85,719	—	74,069	26	28,661	3,829	1,878	—	994	33	665,707	126.08
Arlington,	—	—	—	—	—	—	—	—	—	—	—	24,136	29,088	40,693	—	149,532	15,617	259,066	49.07
Belmont,	—	—	—	—	—	—	—	—	—	—	—	5,714	16,954	26,777	—	114,262	269	163,976	31.06
Boston,	10,607	15,683	16,081	37,132	93,787	79,147	87,071	87,071	—	267,537	5,041	1,457,595	400,726	830,867	—	1,212,784	102,925	4,616,983	874.43
Chelsea,	—	—	—	—	—	—	—	—	—	5,176	5,998	6,084	42,876	25,930	—	143,240	6,656	230,045	43.68
Everett,	—	—	—	—	—	—	2,434	2,900	—	5,204	5,998	6,084	42,876	25,930	—	146,697	30,600	268,773	50.90
Lexington,	—	—	—	—	—	—	—	—	—	—	—	9,000	4,879	35,433	—	120,691	27,794	197,797	37.46
Malden,	—	—	—	—	—	—	—	—	—	8,891	9,179	83,922	31,300	89,850	—	225,696	51,318	500,156	94.73
Medford,	—	—	—	—	—	—	—	673	—	6,775	9,598	32,600	39,447	98,578	—	168,912	26,348	382,931	72.52
Melrose,	—	—	—	—	—	—	—	—	—	5,224	3,024	23,097	20,334	25,720	—	182,619	55,929	285,947	54.16
Milton,	—	—	—	—	—	—	—	—	103	44	44	22,556	20,926	54,526	—	156,640	17,551	272,346	51.58
Nahant,	—	—	—	—	—	—	—	—	—	—	4,000	150	11,550	4,800	—	36,800	57,218	114,518	21.69
Quincy,	—	—	—	—	—	—	—	2,673	—	23,232	29,840	44,543	143,450	994	—	381,532	95,371	721,641	136.67
Revere, ¹	—	—	—	—	—	—	—	—	—	23,813	6,970	24,499	28,037	34,690	—	104,227	71,808	234,044	55.69
Somerville,	—	—	—	—	—	—	—	4,210	307	4,135	7,950	92,335	57,564	108,010	—	214,640	21,575	510,786	96.74
Stoneham,	—	—	—	—	—	—	—	—	—	—	—	7,425	1,825	5,110	—	108,415	18,567	141,342	26.77
Swampscott,	—	—	—	—	—	—	—	—	—	3,045	6,714	18,306	6,593	—	—	85,555	9,025	129,238	24.48
Watertown,	—	—	—	—	—	—	—	—	—	2,991	11,877	5,959	19,364	27,379	—	142,708	11,816	222,094	42.06
Winthrop,	—	—	—	—	—	—	—	—	—	—	—	4,049	24,073	34,652	—	55,065	55,971	173,810	32.92
Total feet,	43,802	221,699	25,493	22,968	100,758	143,562	167,137	183,252	367	427,150	66,752	1,869,815	855,447	1,625,204	994	3,721,009	676,391	10,151,800	—
Total miles,	8.30	41.99	4.83	4.35	19.08	27.19	31.65	34.71	0.07	80.90	12.64	354.13	162.02	307.80	0.19	704.74	128.10	—	1,922.69

¹ Includes small portion of Saugus.

TABLE NO. 33. — *Number of Service Pipes, Meters, Per Cent of Services metered, Fire Services and Fire Hydrants in the Several Cities and Towns supplied by the Metropolitan Water Works, Dec. 31, 1919.*

CITY OR TOWN.	Services.	Meters.	Per Cent of Services Metered.	Services used for Fire Purposes only.	Fire Hydrants.
Arlington,	3,246	3,246	100.00	15	511
Belmont,	1,794	1,794	100.00	3	275
Boston,	105,978	64,078	60.46	1,735	9,741
Chelsea,	5,243	5,210	99.37	57	401
Everett,	6,093	4,081	66.98	20	647
Lexington,	1,326	1,310	98.79	6	222
Malden,	8,229	7,999	97.21	48	631
Medford,	6,771	6,771	100.00	19	727
Melrose,	4,431	4,386	98.98	19	384
Milton,	2,170	2,170	100.00	1	443
Nahant,	766	568	74.15	—	102
Quincy,	10,831	9,837	90.82	15	1,233
Revere, ¹	4,824	3,841	79.62	4	314
Somerville,	13,524	10,450	77.27	37	1,241
Stoneham,	1,674	1,672	99.88	—	156
Swampscott,	1,988	1,988	100.00	2	202
Watertown,	3,355	3,355	100.00	21	423
Winthrop,	2,997	2,983	99.53	5	320
Totals,	185,240	135,739	73.28	2,007	17,973

¹ Includes small portion of Saugus.

TABLE No. 34. — *Elevation of the Hydraulic Grade Line, in Feet, above Boston City Base for Each Mouth at Stations on Metropolitan Water Works during 1919.*

1919. MONTH.	LOW SERVICE.										SOUTHERN HIGH SERVICE.								
	BOSTON ENGINE HOUSE, BULFINCH STREET.		ALLSTON ENGINE HOUSE, HARVARD STREET.		MEDFORD, NEAR MYSTIC RESERVOIR.		SOMERVILLE PUBLIC LIBRARY, HIGHLAND AVENUE.		MALDEN WATER WORKS SHOP, GREEN STREET.		CHELSEA COURT HOUSE.		BOSTON METRO- POLITAN WATER WORKS OFFICE, 1 ASHBURTON PLACE.		WATERTOWN WATER WORKS OFFICE, MAIN STREET.		BELMONT WATER WORKS SHOP, WAVE- LEY STREET.		
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.
January, .	146	138	178	170	164	160	167	161	166	163	161	153	244	225	257	235	258	246	234
February, .	147	139	177	168	165	162	167	161	166	163	163	153	245	226	254	234	257	245	245
March, .	154	145	175	168	166	163	166	161	166	162	166	154	247	228	261	249	257	245	245
April, .	155	145	179	169	167	162	167	162	166	163	166	155	248	228	260	250	257	243	243
May, .	152	141	181	171	167	163	166	160	166	163	166	153	247	228	258	248	257	242	242
June, .	153	143	179	172	168	164	168	161	166	162	165	152	245	226	257	241	258	234	234
July, .	152	143	178	172	168	164	168	161	165	162	165	153	246	228	258	243	258	240	240
August, .	151	142	176	169	167	164	167	161	165	161	164	151	245	228	257	247	257	247	247
September, .	151	139	174	167	167	162	166	160	165	161	165	152	244	225	257	245	258	248	248
October, .	152	142	178	169	167	162	168	160	166	161	165	152	244	224	258	245	258	247	247
November, .	154	143	177	168	166	162	167	160	167	162	165	154	245	226	259	244	260	248	248
December, .	150	139	178	170	166	162	165	160	166	161	165	151	244	226	259	244	259	249	249
Averages, .	151	142	178	169	167	163	167	161	166	162	165	153	245	227	258	244	258	245	245

TABLE No. 34. — *Elevation of the Hydraulic Grade Line, in Feet, above Boston City Base, etc. — Concluded.*

1919. MONTH.	SOUTHERN HIGH SERVICE — Concluded.								NORTHERN HIGH SERVICE.								NORTHERN EXTRA HIGH SERVICE.	
	MILTON WATER WORKS OFFICE, ADAMS STREET.		FORBES HILL TOWER, QUINCY.		QUINCY WATER WORKS SHOP.		SOMERVILLE PUMPING STA- TION, CEDAR STREET.		MALDEN CITY HALL.		REVERE WATER WORKS OFFICE, BROADWAY.		LYNN ENGINE HOUSE, UNION SQUARE.		WINTHROP TOWN HALL, HERMAN MASSACHUSETTS AVENUE.		Maximum.	Minimum.
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.		
January, .	242	229	235	222	230	210	267	244	268	264	254	245	253	241	192	179	—	—
February, .	244	228	232	217	227	204	269	244	269	263	252	244	250	239	193	180	433	426
March, .	245	231	232	218	231	203	267	243	269	262	262	253	260	249	194	180	433	424
April, .	247	232	231	218	230	206	268	243	269	263	260	252	259	248	193	179	434	427
May, .	247	231	237	219	232	204	268	244	270	263	258	247	256	240	192	177	434	425
June, .	245	227	237	217	232	201	267	238	268	260	255	237	248	220	189	168	431	416
July, .	246	230	236	217	232	200	267	243	266	259	255	236	245	212	186	165	427	413
August, .	245	231	235	220	232	206	268	249	268	260	255	241	249	225	186	170	426	417
September, .	245	229	236	220	233	208	267	244	267	262	260	248	252	234	187	172	426	416
October, .	247	230	237	221	235	210	268	244	269	262	263	252	258	243	188	175	426	416
November, .	—	—	237	222	236	213	269	243	269	262	261	251	260	245	188	175	432	421
December, .	247	230	235	222	232	208	269	243	269	262	263	249	256	244	187	175	432	423
Averages, .	245	230	235	219	232	206	268	244	268	262	258	246	254	237	190	175	430	420

APPENDIX NO. 3.

WATER WORKS STATISTICS FOR THE YEAR 1919.

The Metropolitan Water Works supply the Metropolitan Water District, which includes the following cities and towns:—

CITY OR TOWN.	Population, Census of 1915.	Estimated Population, July 1, 1919.
Arlington,	14,889	17,530
Belmont,	8,081	9,710
Boston,	745,439	804,140
Chelsea,	43,426	48,840
Everett,	37,718	41,610
Lexington,	5,538	6,020
Malden,	48,907	53,150
Medford,	30,509	35,860
Melrose,	16,880	18,170
Milton,	8,600	9,450
Nahant,	1,387	1,570
Newton, ¹	43,113	45,990
Quincy,	40,674	45,280
Revere,	25,178	30,640
Somerville,	86,854	94,800
Stoneham,	7,489	7,840
Swampscott,	7,345	8,160
Watertown,	16,515	19,140
Winthrop,	12,758	15,170
Total population of Metropolitan Water District, . . .	1,201,300	1,313,070
Saugus, ²	280	280

¹ No water supplied during the year from Metropolitan Water Works.

² Only a small portion of Saugus was supplied with water.

*Pumping.**Chestnut Hill Pumping Station No. 1:—*

Builders of pumping machinery, Holly Manufacturing Company, Quintard Iron Works and E. P. Allis Company.

Description of coal used: — Bituminous: 72.9 per cent Nanty-Glo and Davenport. Anthracite: screenings 27.1 per cent. Price per gross ton in bins: bituminous \$6.89 to \$7.35, screenings \$5.71 to \$6.09. Average price per gross ton \$6.95. Per cent ashes 13.6.

Chestnut Hill Pumping Station No. 2: —

Builders of pumping machinery, Holly Manufacturing Company.

Description of coal used: — Bituminous: 73.5 per cent Nanty-Glo, Davenport and Ake. Anthracite: screenings 26.5 per cent. Price per gross ton in bins: bituminous \$5.79 to \$7.05, screenings \$4.95 to \$5.55. Average price per gross ton \$5.81. Per cent ashes 15.2.

Spot Pond Station: —

Builders of pumping machinery, Geo. F. Blake Manufacturing Company and Holly Manufacturing Company.

Description of coal used: — Bituminous: 60.3 per cent Davenport, Nanty-Glo and Ake. Anthracite: screenings 39.7 per cent. Price per gross ton in bins: bituminous \$6.99 to \$8.40, screenings \$4.95 to \$5.88. Average price per gross ton \$6.86. Per cent ashes 14.4.

Chestnut Hill Pumping Station No. 1.

	Engines Nos. 1 and 2.	Engine No. 3.	Engine No. 4.	Totals.
Daily pumping capacity (gallons),	16,000,000	20,000,000	30,000,000	66,000,000
Coal consumed for year (pounds),	—	—	—	4,444,385
Cost of pumping, figured on pumping station expenses.	—	—	—	\$42,556 87
Total pumpage for year, corrected for slip (million gallons).	1,365.57	165.96	926.23	2,457.76
Average dynamic head (feet),	133.06	128.05	125.08	129.71
Cost per million gallons pumped,	—	—	—	\$17.3153
Cost per million foot gallons,	—	—	—	.1335

Chestnut Hill Pumping Station No. 2.

	Engines Nos. 5, 6 and 7.	Engine No. 12.	Totals.
Daily pumping capacity (gallons),	105,000,000	40,000,000	145,000,000
Coal consumed for year (pounds),	—	—	13,199,141
Cost of pumping, figured on pumping station expenses, .	—	—	\$103,475 51
Total pumpage for year, corrected for slip (million gallons).	10,597.89	12,710.09	23,307.98
Average dynamic head (feet),	29.70	122.48	80.29
Cost per million gallons pumped,	—	—	\$4.4395
Cost per million foot gallons,	—	—	.0553

Spot Pond Pumping Station.

	Engines Nos. 8 and 9.
Daily pumping capacity (gallons),	30,000,000
Coal consumed for year (pounds),	3,182,051
Cost of pumping, figured on pumping station expenses,	\$26,223 03
Total pumpage for year, corrected for slip (million gallons),	3,059.80
Average dynamic head (feet),	132.60
Cost per million gallons pumped,	\$8.5702
Cost per million foot gallons,0646

Consumption.

Estimated total population of the eighteen cities and towns supplied wholly or partially during the year 1919,	1,267,080
Total consumption (gallons), meter basis,	44,016,611,000 ¹
Average daily consumption (gallons), meter basis,	120,593,500
Gallons per day to each inhabitant, meter basis,	95.2

Distribution.

	Metropolitan Water Works.	Cities and Towns supplied by Metropolitan Water Works.
Kinds of pipe used,	- ²	- ²
Sizes,	76-4 inch.	48-4 inch.
Extensions, less length abandoned (miles),	1.81	10.18
Length in use (miles),	126.03	1,796.61
Stop-gates added,	8	-
Stop-gates now in use,	544	-
Service pipes added,	-	2,191
Service pipes now in use,	-	185,240
Meters added,	-	2,965
Meters now in use,	-	135,739
Fire hydrants added,	-	268
Fire hydrants now in use,	-	17,973

¹ 66.2 per cent pumped; 33.8 per cent by gravity.
² Cast-iron, cement-lined wrought-iron, cement-lined steel and kalamine pipe.

APPENDIX NO. 4.

CONTRACTS MADE AND PENDING DURING

Contracts relating to the

1. Number of Contract.	2. WORK.	3. Num- ber of Bids.	AMOUNT OF BID.		6. Contractor.
			4. Next to Lowest.	5. Lowest.	
1	144 ¹	-	-	-	Bruno & Petitti, Bos- ton.
2	146 ¹	8	\$19,200 00	\$17,694 00 ²	Rendle-Stoddard Company, Chelsea.
3	147 ¹	2	\$8.95 per ton	\$8.50 per ton ²	Maritime Coal Com- pany, Boston.
		2	\$8.65 per ton	\$8.25 per ton ²	
		2	\$8.62 per ton	\$8.25 per ton ²	
4	148	4	\$30,692 00	\$26,016 00 ²	Rendle-Stoddard Company, Chelsea.

Contracts relating to the

1	138 ¹	3	\$79,040 00	\$54,630 00 ²	Thomas Russo & Co., Boston.
2	139 ¹	3	93,070 00	92,870 00	Rowe Contracting Company, Boston.

¹ Contract completed.

APPENDIX No. 4.

THE YEAR 1919 — SEWERAGE WORKS.

North Metropolitan System.

7. Date of Con- tract.	8. Date of Completion of Work.	9. Prices of Principal Items of Contracts made in 1919.	10. Value of Work done Dec. 31, 1919.	
July 29, 1918	Sept. 11, 1919	- - -	\$69,866 38	1
June 18, 1919	Nov. 26, 1919	For earth excavation and refilling in trench and laying of pipe for 15-inch and 18-inch Akron pipe sewer, \$3.69 per lin. ft.; for Portland cement brick masonry in manholes and special structures, \$25 per cu. yd.; for Portland cement concrete masonry in trench and special structures \$9.20 per cu. yd.; for bank gravel refill around pipe sewer in trench, \$3 per cu. yd.	17,598 51	2
May 28, 1919	Oct. 15, 1919	\$8.50 per ton of 2,240 pounds delivered in bins at Deer Island pumping station.	17,956 62	3
		\$8.25 per ton of 2,240 pounds delivered in bins at East Boston pumping station.	17,980 05	
		\$8.25 per ton of 2,240 pounds delivered in bins at Charlestown pumping station.	7,425 00	
Sept. 17, 1919	-	For earth excavation and refilling in trench and laying of pipe for 15-inch, 18-inch, and 20-inch Akron pipe sewer, \$6.10 per lin. ft.; for Portland cement brick masonry in manholes and special structures, \$30 per cu. yd.; for Portland cement concrete masonry in trench and special structures, \$15 per cu. yd.; for bank gravel refill around pipe sewer in trench, \$2 per cu. yd.; for rock excavation in trench, \$7 per cu. yd.	22,429 93	4

South Metropolitan System.

July 13, 1916	July 17, 1919	Work abandoned by the Contractor before any portion was completed. Work provided for is now being completed in accordance with the specifications by Geo. M. Bryne.	\$226,480 79	1
June 7, 1918	Nov. 5, 1919	- - -	82,255 95	2

² Contract based upon this bid.

CONTRACTS MADE AND PENDING DURING

Contracts relating to the

	1. Number of Contract.	2. WORK.	3. Num- ber of Bids.	AMOUNT OF BID.		6. Contractor.
				4. Next to Lowest.	5. Lowest.	
3	145	Section 101, High-level sewer, Wellesley Extension, South Metropolitan System in Dedham and Needham.	5	\$90,080 00	\$72,046 60 ¹	Rendle-Stoddard Company, Chelsea.
4	147 ²	400 tons of coal for Nut Island screen-house.	2	\$8.80 per ton	\$8.60 per ton ¹	Maritime Coal Company, Boston.
5	149	Part of Section 99, High-level sewer, Wellesley Extension, South Metropolitan System in Dedham.	6	\$67,800 00	\$47,675 00 ¹	John C. Cavanagh Company, Boston.

¹ Contract based upon this bid.

THE YEAR 1919 — SEWERAGE WORKS — *Continued.**South Metropolitan System — Concluded.*

7. Date of Con- tract.	8. Date of Completion of Work.	9. Prices of Principal Items of Contracts made in 1919.	10. Value of Work done Dec. 31, 1919.	
Sept. 17, 1919	-	For earth excavation and refilling in trench and embankment for 33-inch by 36-inch and 27-inch by 30-inch concrete sewer and 16-inch cast-iron pipe siphon crossing Charles River, \$9.24 per lin. ft.; for Portland cement brick masonry in manholes, siphon head-houses and special structures, \$30 per cu. yd.; for Portland cement concrete masonry in trench, siphon head-houses, and special structures, \$13.74 per cu. yd.; for spruce piles in trench and river bed in place, \$0.65 per lin. ft.; for rock excavation in trench, \$7 per cu. yd.	-	3
May 28, 1919	Oct. 15, 1919	\$8.60 per ton of 2,240 pounds delivered on wharf at Nut Island screen-house.	\$2,992 80	4
Sept. 29, 1919	-	For earth excavation and refilling in trench for 33-inch by 36-inch concrete sewer and 30-inch cast-iron pipe, \$18.50 per lin. ft.; for Portland cement brick masonry in manholes and special structures, \$30 per cu. yd.; for Portland cement concrete masonry in trench and special structures, \$16 per cu. yd.; for spruce piles in trench and river bed in place, \$0.40 per lin. ft.; for rock excavation in trench, \$9 per cu. yd.	1,060 00	5

² Contract completed.

CONTRACTS MADE AND PENDING DURING THE YEAR 1919 — SEWERAGE WORKS
— *Concluded.*

Summary of Contracts.

	Value of Work done Dec. 31, 1919.
North Metropolitan System, 4 contracts,	\$153,256 49
South Metropolitan System, 5 contracts,	312,789 54
Total of 9 contracts made and pending during the year 1919,	\$466,046 03

APPENDIX No. 5.

FINANCIAL STATEMENT PRESENTED TO THE GENERAL COURT ON JANUARY 6, 1920.

The Metropolitan District Commissioner respectfully presents the following abstract of the account of the receipts, expenditures, disbursements, assets and liabilities of the Metropolitan Water and Sewerage Board for the year ending November 30, 1919, together with recommendations for legislation, in accordance with the provisions of chapter 235 of the Acts of the year 1906.

METROPOLITAN WATER WORKS.

Construction.

The loans authorized for expenditures under the Metropolitan Water acts, the receipts which are added to the loan fund, the expenditures for the construction and acquisition of works, and the balance available on December 1, 1919, have been as follows:—

Loans authorized under Metropolitan Water acts, including appropriations under Gen. Sts. 1919, cs. 165, 166 and 167, to provide an additional water supply for the town of Milton, the Hyde Park and the East Boston districts of the city of Boston, and the town of Lexington, respectively,	\$42,980,000 00
Receipt from town of Swampscott for admission to Metropolitan Water District, paid into Loan Fund (St. 1909, c. 320),	90,000 00
Receipts from the sales of property which are placed to the credit of the Metropolitan Water Loan Fund:—	
For the year ending November 30, 1919, . . .	\$1,755 25
For the period prior to December 1, 1918, . . .	257,143 42
	<hr/> 258,898 67
	\$43,328,898 67
Amount approved for payment by the Board out of the Metropolitan Water Loan Fund:—	
For the year ending November 30, 1919, . . .	\$93,758 90
For the period prior to December 1, 1918, . . .	43,153,743 56
	<hr/> 43,247,502 46
Balance December 1, 1919,	\$81,396 21

The amount of the Metropolitan Water Loan bonds issued at the end of the fiscal year was \$42,913,000, bonds to the amount of \$161,000 having been issued during the year. Of the total amount issued, \$41,398,000 were sinking fund bonds, and the remainder, amounting to \$1,515,000, were issued as serial bonds.

At the end of the year the amount of outstanding bonds was \$42,735,000, as bonds issued on the serial payment plan to the amount of \$178,000 had been paid. During the fiscal year \$37,000 in serial bonds has been paid.

The Metropolitan Water Loan Sinking Fund amounted on December 1, 1919, to \$15,904,545.14, an increase during the year of \$1,033,710.30.

Maintenance.

Amount appropriated for the maintenance and operation of works for the year ending November 30, 1919,	\$647,200 00	
Special appropriation for protection of water supply aqueducts (1911) remaining,	9,930 60	
Special appropriations for protection and improvement of the water supply (1912, 1913, 1916 and 1918) remaining,	26,260 97	
Receipts credited to this fund for the year ending November 30, 1919,	5,728 12	
	<hr/>	\$689,119 69
Amount approved by Board for maintenance and operation of works during the year ending November 30, 1919,	\$631,835 95	
Deduct amount paid from appropriation for the year 1918,	22,738 73	
	<hr/>	609,097 22
Balance December 1, 1919,		<hr/> \$80,022 47

This balance includes the sum of \$9,930.60, the amount remaining unexpended of the special appropriation for the protection of the water supply in aqueducts, and the sums of \$2,713.93, the amount remaining unexpended of the special appropriation in 1912, \$0.89 of the special appropriation in 1913, \$714.89 of the special appropriation in 1916 and \$17,347.05 of the appropriation in 1918 for the protection and improvement of the water supply.

The Board has also received during the year ending November 30, 1919, \$85,971.59 from rentals, the sale of land, land products and power and from other proceeds from the operations of the Board, which, according to section 18 of the Metropolitan Water Act, are applied by the Treasurer of the Commonwealth to the payment of interest on the Metropolitan Water Loan, to sinking fund requirements, and expenses of maintenance and operation of works, in reduction of the amount to be assessed upon the Metropolitan Water District for the year.

Sums received from sales of water to municipalities not belonging to the District and to water companies, and from municipalities for admission to the District, have been applied as follows:—

For the period prior to December 1, 1906, distributed to the cities and towns of the District, as provided by section 3 of the Metropolitan Water Act,	\$219,865 65
For the period beginning December 1, 1906, and prior to December 1, 1918, applied to the Metropolitan Water Loan Sinking Fund, as provided by chapter 238 of the Acts of 1907,	\$8,638 56
For the year beginning December 1, 1918, and ending November 30, 1919, applied to the Metropolitan Water Loan Sinking Fund as provided by said last-named act,	9,789 38
	<hr/>
	\$318,293 59

METROPOLITAN SEWERAGE WORKS.

Construction.

The loans authorized under the various acts of the Legislature for the construction of the Metropolitan Sewerage Works, the receipts which are added to the proceeds of the loans, and the expenditures for construction, are given below, as follows:—

North Metropolitan System.

Loans authorized for expenditures for construction under the various acts, including those for the Revere, Belmont and Malden extensions, North System enlargements and extensions, New Mystic Sewer, Deer Island outfall extension, lowering sewer siphon under Malden River, balance of appropriation under chapter 76, Resolves of 1915, and for the Reading Extension,	\$7,512,365 73
	<hr/>
<i>Amount carried forward,</i>	\$7,512,365 73

Amount brought forward, \$7,512,365 73

Receipts from sales of real estate and from miscellaneous sources, which are placed to the credit of the North Metropolitan System:—

For the year ending November 30, 1919, 61 95

For the period prior to December 1, 1918, 86,021 19

Amount approved for payment by the Board¹ out of the Metropolitan Sewerage Loan Fund, North System:—

For the year ending November 30, 1919, \$104,312 98

For the period prior to December 1, 1918, 7,324,251 94

\$7,598,448 87 \$7,428,564 92

Balance December 1, 1919, \$169,883 95

South Metropolitan System.

Loans authorized for expenditures for construction under the various acts, applied to the construction of the Charles River valley sewer, Neponset valley sewer, High-level sewer and extensions (including Wellesley Branch), and an additional appropriation authorized by chapter 237, General Acts of 1919, and for additional Ward Street station pumping plant, . . \$9,812,046 27

Receipts from pumping, sales of real estate and from miscellaneous sources, which are placed to the credit of the South Metropolitan System:—

For the year ending November 30, 1919, 269 62

For the period prior to December 1, 1918, 19,415 03

Amount approved by Board for payment as follows:—

On account of the Charles River valley sewer, \$800,046 27

On account of the Neponset valley sewer, 911,531 46

On account of the High-level sewer and extensions:—

For the year ending November 30, 1919, 120,557 92

For the period prior to December 1, 1918, 7,758,592 91

\$9,831,730 92 \$9,590,728 56

Balance December 1, 1919, \$241,002 36

¹ The word "Board" refers to the Metropolitan Sewerage Commission and its successor, the Metropolitan Water and Sewerage Board.

The amount of the Metropolitan Sewerage Loan bonds issued at the end of the fiscal year was \$17,086,412, no additional bonds having been issued during the year. Of the total amount issued, \$15,440,912 were sinking fund bonds, and the remainder, amounting to \$1,645,500, were serial bonds.

At the end of the year the amount of the outstanding bonds was \$16,895,412, as bonds issued on the serial payment plan to the amount of \$47,500 had been paid during the year, \$191,000 having been paid to December 1, 1919.

Of the total amount outstanding at the end of the year, \$7,360,500 were issued for the North Metropolitan System and \$9,534,912 for the South Metropolitan System. The Metropolitan Sewerage Loan Sinking Fund amounted on December 1, 1919, to \$4,695,573.07, of which \$2,946,215.08 was on account of the North Metropolitan System and \$1,749,357.99 was on account of the South Metropolitan System, an increase during the year of \$425,367.57.

The net debt on December 1, 1919, was \$12,199,838.93, a decrease of \$472,867.57.

Included in the above figures for the North Metropolitan System is \$925,500 in serial bonds, of which \$128,000 has been paid, and \$720,000 for the South Metropolitan System, of which \$63,000 has been paid.

Maintenance.

North Metropolitan System.

Appropriated for the year ending November 30, 1919,	\$260,000 00
Receipts from pumping and from other sources, which are returned to the appropriation: —	
For the year ending November 30, 1919,	2,098 43
	<hr/>
	\$262,098 43
Amount approved for payment by the Board: —	
For the year ending November 30, 1919,	\$233,865 68
Deduct amount paid from appropriation for the year 1918,	15,090 46
	<hr/>
	218,775 22
	<hr/>
Balance December 1, 1919,	\$43,323 21

South Metropolitan System.

Appropriated for the year ending November 30, 1919,	\$152,000 00	
Receipts from sales of property, reimbursement and for pumping, which are returned to the appropriation: —		
For the year ending November 30, 1919,	397 76	
	<hr/>	\$152,397 76
Amount approved for payment by the Board: —		
For the year ending November 30, 1919,	\$147,528 39	
Deduct amount paid from appropriation for the year		
1918,	11,000 91	
	<hr/>	136,527 48
		<hr/>
Balance December 1, 1919,	\$15,870 28	

APPENDIX No. 6.

LEGISLATION OF THE YEAR 1919 AFFECTING THE
METROPOLITAN WATER AND SEWERAGE BOARD.

General Acts, 1919.

CHAPTER 2.

AN ACT RELATIVE TO THE INTEREST ON BONDS ISSUED TO
PROVIDE FOR THE COMPLETION OF CERTAIN AUTHORIZED
IMPROVEMENTS IN THE METROPOLITAN WATER WORKS.

Whereas, The finances of the commonwealth require the immediate sale of the securities mentioned in the following act, and it is not possible to sell the same without raising the rate of interest thereon as fixed by law, it is accordingly hereby declared that the act, being necessary for the immediate preservation of the public convenience, is an emergency measure, therefore

Be it enacted, etc., as follows:

SECTION 1. Chapter one hundred and fifty-seven of the General Acts of nineteen hundred and eighteen is hereby amended by adding at the end thereof the words: — The rate of interest to be paid under the provisions of this act shall be such as the treasurer and receiver general, with the approval of the governor and council, may determine, — so as to read as follows: — The treasurer and receiver general, in order to provide for the increased cost of constructing a line for the transmission of electricity between the power station at the Wachusett dam in Clinton and the power station at the Sudbury dam in Southborough, to relocate and connect meters for the measuring of water supplied through the low service to the metropolitan water district, to construct a 12-inch pipe line in Poplar street, West Roxbury, and under the Neponset river, and to install a new pumping engine at the Arlington pumping station, all

1918, 157 (G),
amended.

Rate of interest on bonds for completing certain metropolitan water works improvements.

of which improvements were authorized by chapter one hundred and seventy-two of the General Acts of nineteen hundred and sixteen, shall issue from time to time, upon the request of the metropolitan water and sewerage board, bonds in the name and behalf of the commonwealth and under its seal, to an amount not exceeding four thousand dollars, said sum being the amount of the unexpended balance of six hundred thousand dollars authorized by chapter six hundred and ninety-four of the acts of nineteen hundred and twelve. The rate of interest to be paid under the provisions of this act shall be such as the treasurer and receiver general, with the approval of the governor and council, may determine.

SECTION 2. This act shall take effect upon its passage.
[Approved January 28, 1919.]

CHAPTER 6.

AN ACT RELATIVE TO THE RATE OF INTEREST ON BONDS ISSUED TO PROVIDE AN ADDITIONAL WATER SUPPLY FOR THE TOWNS OF WATERTOWN AND BELMONT.

Whereas, The finances of the commonwealth require the immediate sale of the securities mentioned in the following act, and it is not possible to sell the same without raising the rate of interest thereon as fixed by law, it is accordingly hereby declared that the act, being necessary for the immediate preservation of the public convenience, is an emergency measure, therefore

Be it enacted, etc., as follows:

SECTION 1. Section two of chapter one hundred and seventy-seven of the General Acts of nineteen hundred and eighteen is hereby amended by adding at the end thereof the words: — The rate of interest to be paid under the provisions of this act shall be such as the treasurer and receiver general, with the approval of the governor and council, may determine. The bonds issued under this act shall be designated on the face thereof Metropolitan Water Loan, — so as to read as follows: — *Section 2.* To meet expenses incurred hereunder, the treasurer and receiver general shall, from time to time, issue, upon the request of said board, bonds in the name and behalf of the commonwealth to an

1918, 177 (G),
§ 2, amended.

Rate of interest on bonds for additional water supply for Belmont and Watertown.

amount not exceeding one hundred and fifteen thousand dollars in addition to the sum of forty-two million seven hundred and ninety-eight thousand dollars authorized by chapter four hundred and eighty-eight of the acts of eighteen hundred and ninety-five and acts in amendment thereof and in addition thereto, and the provisions of said chapter and acts shall apply to the loan hereby authorized. The rate of interest to be paid under the provisions of this act shall be such as the treasurer and receiver general, with the approval of the governor and council, may determine. The bonds issued under this act shall be designated on the face thereof Metropolitan Water Loan.

SECTION 2. This act shall take effect upon its passage.
[Approved February 4, 1919.]

CHAPTER 152.

AN ACT TO PROVIDE FOR VACATIONS WITH PAY FOR CERTAIN PERSONS REGULARLY EMPLOYED BY THE COMMONWEALTH.

Be it enacted, etc., as follows:

SECTION 1. All laborers, workmen and mechanics, who are within the provisions of chapter four hundred and ninety-four of the acts of nineteen hundred and eleven, and amendments, and who are permanently in the service or employ of the commonwealth, of the metropolitan water and sewerage board or of the metropolitan park commission shall be entitled to an annual vacation of not less than twelve working days with pay.

Vacations of certain employees of commonwealth.

SECTION 2. This act shall take effect on the first day of December, nineteen hundred and nineteen. [Approved May 3, 1919.]

Time of taking effect.

CHAPTER 161.

AN ACT TO AUTHORIZE THE CONSTRUCTION OF A MAIN TRUNK SEWER TO CONNECT THE TOWN OF READING WITH THE NORTH METROPOLITAN SEWERAGE SYSTEM.

Be it enacted, etc., as follows:

Section two of chapter one hundred and fifty-nine of the General Acts of nineteen hundred and sixteen, as amended by chapter three of the General Acts of nineteen hundred

1916, 259 (G), § 2, amended.

Metropolitan water and sewerage board to provide outlet for sewage of Reading.

and seventeen, is hereby further amended by inserting after the word "sewers", in the fifth line, the words:— and other works in and, — so as to read as follows:— *Section 2.* The metropolitan water and sewerage board shall provide an outlet at the Reading town line in or near Brook street for the sewage of said town, and, acting on behalf of the commonwealth shall construct a main trunk sewer or sewers and other works in and through such parts of the towns of Reading, Wakefield and Stoneham and the city of Woburn from the Reading town line to such point in the north metropolitan system as said board may determine to be necessary in order to connect with a main trunk sewer in the Mystic valley. [*Approved May 13, 1919.*]

CHAPTER 165.

AN ACT TO AUTHORIZE THE METROPOLITAN WATER AND SEWERAGE BOARD TO PROVIDE AN ADDITIONAL WATER SUPPLY FOR THE TOWN OF MILTON AND THE HYDE PARK DISTRICT OF THE CITY OF BOSTON.

Be it enacted, etc., as follows:

Additional water supply for Milton and Hyde Park.

SECTION 1. The metropolitan water and sewerage board is hereby authorized to construct a twelve-inch metropolitan water main in Poplar street, West Roxbury, and under Neponset river, to provide an additional supply of water for Milton and the Hyde Park district of the city of Boston.

Issue of bonds to meet expenses, etc.

SECTION 2. To meet the expenses incurred under the provisions of this act the treasurer and receiver general shall, from time to time, issue upon the request of the said board, bonds in the name and behalf of the commonwealth, and under its seal, to an amount not exceeding fourteen thousand dollars, in addition to the sum of forty-two million nine hundred and thirteen thousand dollars heretofore authorized to be issued by chapter four hundred and eighty-eight of the acts of eighteen hundred and ninety-five, and acts in amendment thereof and in addition thereto. The bonds hereby authorized shall bear such rates of interest as the treasurer and receiver general, with the approval of the governor and council, may fix and shall be for terms not exceeding forty years, as recommended by the governor in his message to the general court dated April

twenty-fourth, nineteen hundred and nineteen, in accordance with section three of Article LXII of the amendments to the constitution; and the provisions of said chapter four hundred and eighty-eight and acts in amendment thereof and in addition thereto shall otherwise, so far as they are applicable, apply to the indebtedness and proceedings authorized by this act. [Approved May 14, 1919.

CHAPTER 166.

AN ACT TO ENABLE THE METROPOLITAN WATER AND SEWERAGE BOARD TO PROVIDE AN ADDITIONAL WATER MAIN FOR THE SUPPLY OF THE EAST BOSTON DISTRICT OF THE CITY OF BOSTON.

Be it enacted, etc., as follows:

SECTION 1. To enable the metropolitan water and sewerage board to construct a thirty-six-inch water main, about eighteen hundred feet in length, to provide an additional water supply for the East Boston district of the city of Boston, the board is hereby authorized to use the unexpended balance of twenty-nine thousand eight hundred and twenty dollars and eighty-six cents of the sum authorized for said purpose by chapter three hundred and twenty-two of the General Acts of nineteen hundred and seventeen.

Additional
water supply
for East
Boston.

SECTION 2. To meet further expenditures to be incurred under this act the treasurer and receiver general shall, from time to time, issue upon the request of the said board, bonds in the name and behalf of the commonwealth, and under its seal, to an amount not exceeding eleven thousand dollars, in addition to the sum of forty-two million nine hundred and thirteen thousand dollars heretofore authorized to be issued by chapter four hundred and eighty-eight of the acts of eighteen hundred and ninety-five and acts in amendment thereof and in addition thereto. The bonds hereby authorized shall bear such rates of interest as the treasurer and receiver general, with the approval of the governor and council, may fix and shall be for terms not exceeding forty years, as recommended by the governor in his message to the general court dated April twenty-fourth, nineteen hundred and nineteen, in accordance with section three of Article LXII of the amendments to the constitution; and the provisions of said chapter four hundred and

Issue of bonds
to meet
expenses, etc.

eighty-eight and acts in amendment thereof and in addition thereto shall otherwise, so far as they are applicable, apply to the indebtedness and proceedings authorized by this act. [Approved May 14, 1919.]

CHAPTER 167.

AN ACT TO AUTHORIZE THE METROPOLITAN WATER AND SEWERAGE BOARD TO PROVIDE AN ADDITIONAL SUPPLY OF WATER FOR THE TOWN OF LEXINGTON.

Be it enacted, etc., as follows:

Additional
water supply
for Lexington.

SECTION 1. The metropolitan water and sewerage board is hereby authorized to construct a sixteen-inch metropolitan water main for a distance of about six thousand feet from the standpipe in Arlington to the boundary line between Arlington and Lexington.

Issue of bonds
to meet
expenses, etc.

SECTION 2. To meet the expenditures to be incurred under this act, the said board is authorized to use the unexpended balance of fourteen thousand four hundred and eight dollars and ninety-two cents of the sum authorized by chapter one hundred and seventy-seven of the General Acts of nineteen hundred and eighteen, and the treasurer and receiver general shall, from time to time, issue, upon the request of the said board, bonds in the name and behalf of the commonwealth, and under its seal, to an amount not exceeding forty-two thousand dollars, in addition to the sum of forty-two million, nine hundred and thirteen thousand dollars heretofore authorized to be issued by chapter four hundred and eighty-eight of the acts of eighteen hundred and ninety-five, and acts in amendment thereof and in addition thereto. The bonds hereby authorized shall bear such rates of interest as the treasurer and receiver general, with the approval of the governor and council, may fix and shall be for terms not exceeding forty years, as recommended by the governor in his message to the general court dated April twenty-fourth, nineteen hundred and nineteen, in accordance with section three of Article LXII of the amendments to the constitution; and the provisions of said chapter four hundred and eighty-eight, and acts in amendment thereof and in addition thereto shall otherwise, so far as they are applicable, apply to the indebtedness and proceedings authorized by this act. [Approved May 14, 1919.]

CHAPTER 237.

AN ACT TO PROVIDE FOR THE COMPLETION BY THE METROPOLITAN WATER AND SEWERAGE BOARD OF THE WELLESLEY EXTENSION OF THE SOUTH METROPOLITAN SEWERAGE SYSTEM.

Be it enacted, etc., as follows:

The treasurer and receiver general, in order to provide for the completion of the extension of the high-level sewer authorized by chapter three hundred and forty-three of the acts of nineteen hundred and fourteen, shall, with the approval of the governor and council, issue from time to time scrip or certificates of debt in the name and behalf of the commonwealth and under its seal, to an amount not exceeding two hundred and twenty-five thousand dollars, in addition to the amount authorized to be issued by said chapter and by chapter two hundred and eighty-five of the General Acts of nineteen hundred and seventeen; the rate of interest thereon to be such as the treasurer and receiver general, with the approval of the governor and council, may fix. The said scrip or certificates shall be issued for terms not exceeding forty years, as recommended by the governor in his message to the general court dated April twenty-fourth, nineteen hundred and nineteen, in accordance with section three of Article LXII of the amendments to the constitution; and the provisions of said chapter three hundred and forty-three and of chapter four hundred and twenty-four of the acts of eighteen hundred and ninety-nine and of all acts in amendment thereof and in addition thereto shall otherwise, so far as they are applicable, apply to the indebtedness and proceedings authorized by this act. [*Approved June 12, 1919.*]

Issue of bonds to meet expenses of completion of Wellesley extension of high-level sewer.

Special Acts, 1919.

CHAPTER 173.

AN ACT TO AUTHORIZE THE CITY OF REVERE TO SELL CERTAIN PROPERTY IN THE TOWN OF SAUGUS.

Be it enacted, etc., as follows:

Revere may
sell certain
property in
Saugus.

SECTION 1. The city of Revere may sell, and the town of Saugus may purchase, the structures, pipes, and other appliances owned by the said city in the said town and used for supplying water to the inhabitants of the town. In case the said city and town are unable to agree upon a price therefor, the same shall be fixed by the metropolitan water and sewerage board, and the price so fixed shall be binding upon the said city and town. In case the said town does not, on or before the first day of September, nineteen hundred and twenty, purchase or agree to purchase the said property, the same may be sold by the said city to any other purchaser.

1889, 382,
repealed.

SECTION 2. Chapter three hundred and eighty-two of the acts of eighteen hundred and eighty-nine, and so much of any other act as is inconsistent herewith, are hereby repealed.

Time of
taking effect.

SECTION 3. Section one of this act shall take effect upon its passage. Section two shall take effect on the first day of September, nineteen hundred and twenty. [*Approved May 9, 1919.*]

Resolves, 1919.

CHAPTER 49.

RESOLVE PROVIDING FOR AN INVESTIGATION BY THE STATE DEPARTMENT OF HEALTH AND THE METROPOLITAN WATER AND SEWERAGE BOARD RELATIVE TO WATER SUPPLY NEEDS AND RESOURCES AND TO THE USE OF GREAT PONDS.

Resolved, That the state department of health and the metropolitan water and sewerage board, acting jointly, shall forthwith proceed to investigate the water supply needs of the inhabitants of the commonwealth, including all questions relating to the quantity of water to be obtained from available sources, its quality, the best methods of protecting the purity of the water, the construction, operation and maintenance of works for storing, conveying and purifying the water, the cost of the same, the damages to property, and all matters pertaining to the subject. The said board shall also consider and report whether any of the great ponds now used as sources of water supply might better be devoted to purposes of public recreation, and shall determine the extent to which boating, fishing or other use of any such sources may properly be authorized. The said board shall have power to employ such engineering and other assistance and to incur such expenses as may be necessary for carrying out the provisions of this resolve, and shall report fully with plans and estimates to the general court on or before the first Wednesday in January in the year nineteen hundred and twenty-one, including in its report drafts of any legislation recommended by it. Before incurring any expense the board shall, from time to time, estimate the amount required therefor, and shall submit the same to the governor and council for their approval, and no expense shall be incurred beyond the amount so estimated and approved. [*Approved June 24, 1919.*]

Investigation of water supply needs and resources of commonwealth to be made by state department of health and metropolitan water and sewerage board.

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